

FEBRUARY 4, 1960

**MACHINE**

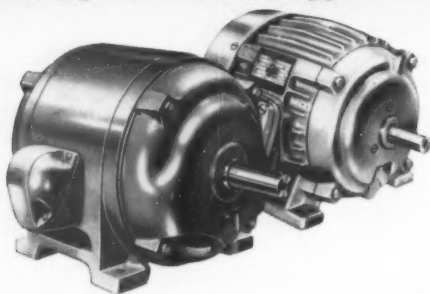
# DESIGN

A PENTON PUBLICATION — BIWEEKLY

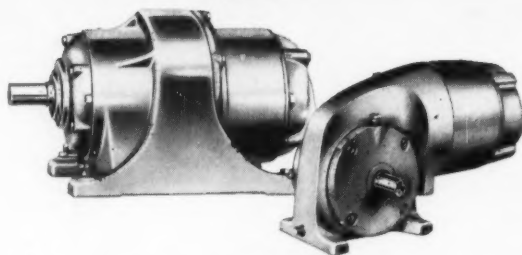


**FLEXURES**

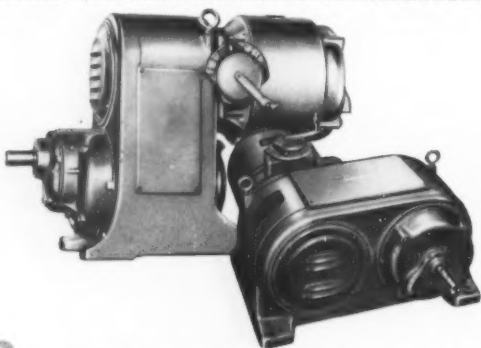
# Which U.S. MOTOR will solve your problem?



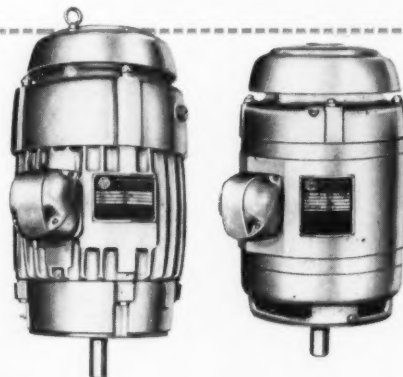
**1 HORIZONTAL MOTORS**, *Uniclosed*, dripproof,  $\frac{1}{2}$  to 250 h.p.; *Totally Enclosed*, 1 to 150 h.p.; *Explosion-Proof*, 1 to 150 h.p. (Other available types not shown)



**2 INTERNALLY GEARED MOTORS**, *Syncrogeared*,  $\frac{1}{3}$  to 30 h.p.; *Syncrogeared Right-Angle* worm-gear,  $\frac{1}{2}$  to 2 h.p. (Other available types not shown)

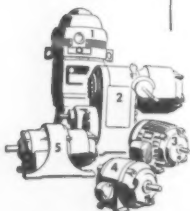


**3 VARIABLE SPEED MOTORS**, *Varidrive*, upright,  $\frac{1}{4}$  to 75 h.p.; *Varidrive*, horizontal,  $\frac{1}{4}$  to 60 h.p. (Other available types not shown)



**4 VERTICAL MOTORS**, *Unimount* vertical solid shaft,  $\frac{1}{2}$  to 500 h.p.; *Unimount Totally-Enclosed*,  $\frac{1}{2}$  to 150 h.p.; *Unimount Explosion-Proof*,  $\frac{1}{2}$  to 150 h.p. (Other available types not shown)

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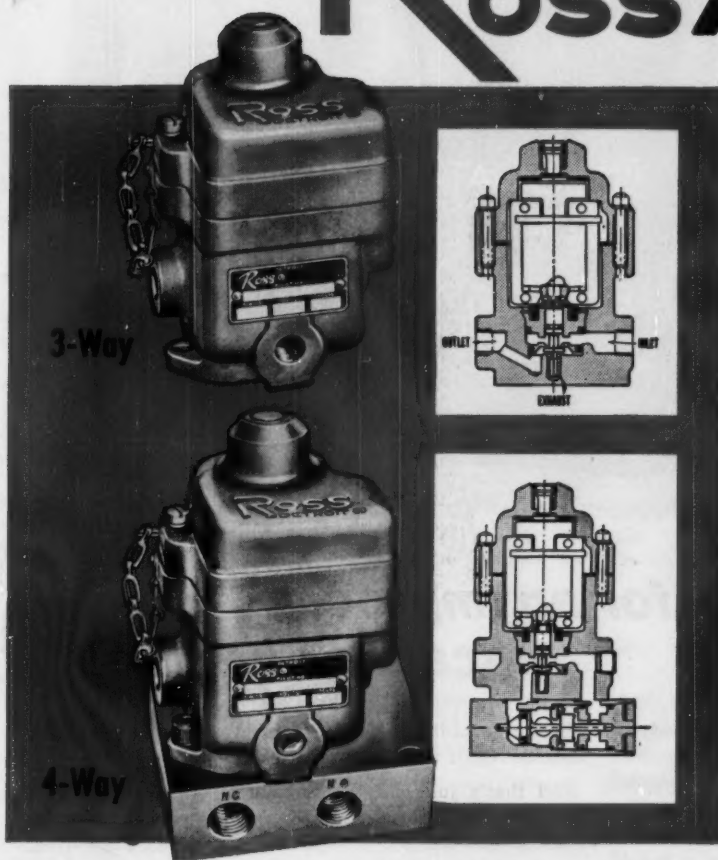
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# Announcing a new and better solenoid valve in the $\frac{1}{8}$ " and $\frac{1}{4}$ " size range

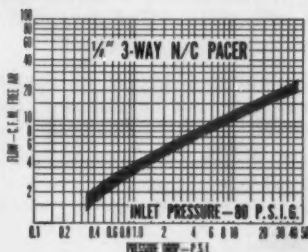
## Ross PACER



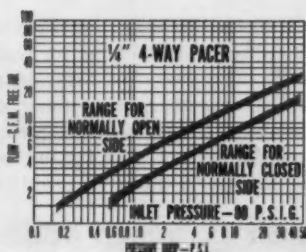
More life  
More speed  
More capacity  
More value

Now you can have about three times more flow capacity-to-solenoid size than in most competitive valves. Needs just 7 watts of power yet minimum internal orifice size is full  $\frac{1}{4}$ ". The PACER has short poppet travel, will cycle at better than 1000 cpm and meets JIC specifications. Lightweight, cast aluminum body means 3-way weighs just 20 ounces, 4-way just 28. Dust tight, liquid tight, can be manually actuated, has captive cover, is inoperative with cover removed, has integral wiring space. Why not test a PACER in your own circuit, just \$18 for a 3-way, \$26 for a PACER 4-way. Call your Ross representative or write for Bulletin 319.

Pressure drop thru 3-way N.C. Pacer valve under steady flow conditions. Inlet pressure 80 psig. Data shown as a range rather than as absolute values due to variables such as barometric pressure, manufacturing tolerances, etc.



Pressure drop thru both N.C. & N.O. sides of 4-way Pacer valve under steady flow conditions. Inlet pressure 80 psig. Data shows ranges for each side rather than absolute values due to variables such as barometric pressure, manufacturing tolerances, etc.



**ROSS OPERATING VALVE COMPANY**  
109 EAST GOLDEN GATE AVE. • DETROIT 3, MICH.



**Blueprint of better design—**

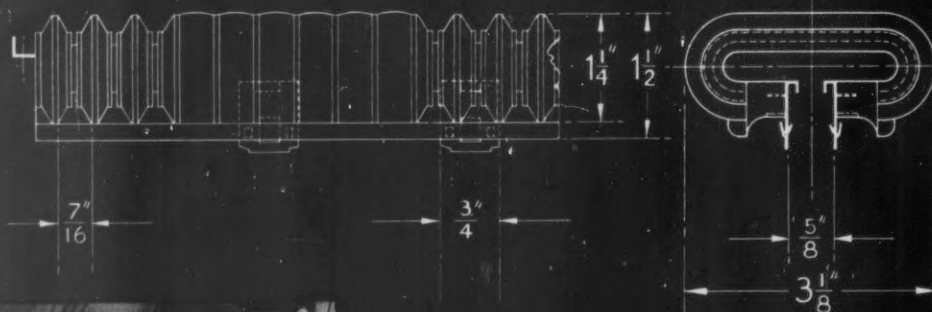


Photo courtesy The Peelle Motorcar

PART NAME				
ESCALATOR HANDRAIL				
SCALE	MODEL	MAT'L	DRAW'G	DATE
0:0	1C	MOLDED RUBBER	1C	1959

## **— for an improved escalator handrail**

The assignment was a tough one—even to Goodyear experts in molded/extruded rubber. For the new handrail design proposed by this escalator manufacturer specified a grip intricately grooved to accommodate attractive metal or plastic inserts—key to a dramatic improvement over the strictly utilitarian escalator rails long in vogue.

Could rubber be molded to this complex design? What about the tough rubber-to-metal bond for fasteners, they asked the G.T.M.—Goodyear Technical Man—and his colleagues. Working together, the rubber experts and escalator men produced the answer: a rugged, articulated rubber rail grooved every half inch for the inserts—these to be offered in the user's choice of beautiful colors or

finishes. And it's unspliced—yet far easier and less expensive to repair than any previous type.

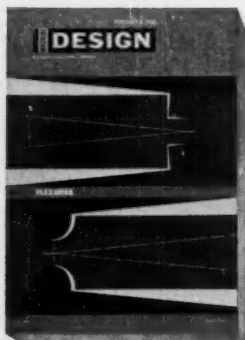
And that's just one more example of the way better designs are made possible by molded rubber, extruded rubber and plastics developed in the modern Goodyear molded/extruded plants. Remember, these unmatched facilities with their skilled personnel and outstanding achievement are at *your* disposal.

For the complete story—or an invitation to see the Goodyear plants and laboratories, contact your local G.T.M. Or write directly to Goodyear, Industrial Products Division, St. Marys, Ohio, Los Angeles 54, California, or Akron 16, Ohio.

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**GOODYEAR**  
**THE GREATEST NAME IN RUBBER**



**Front Cover:** Flexures, as shown by George Farnsworth, are bearings for limited motion. Design article by Victor Billig starts on Page 114.

February 4, 1960

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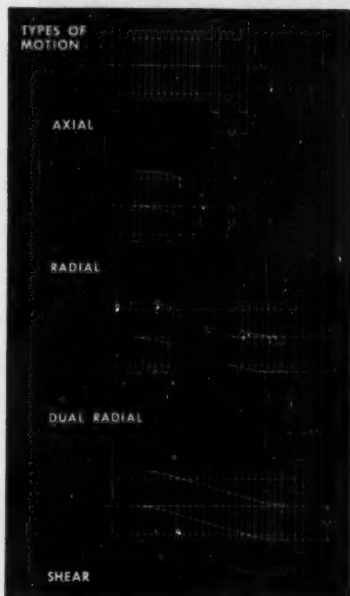
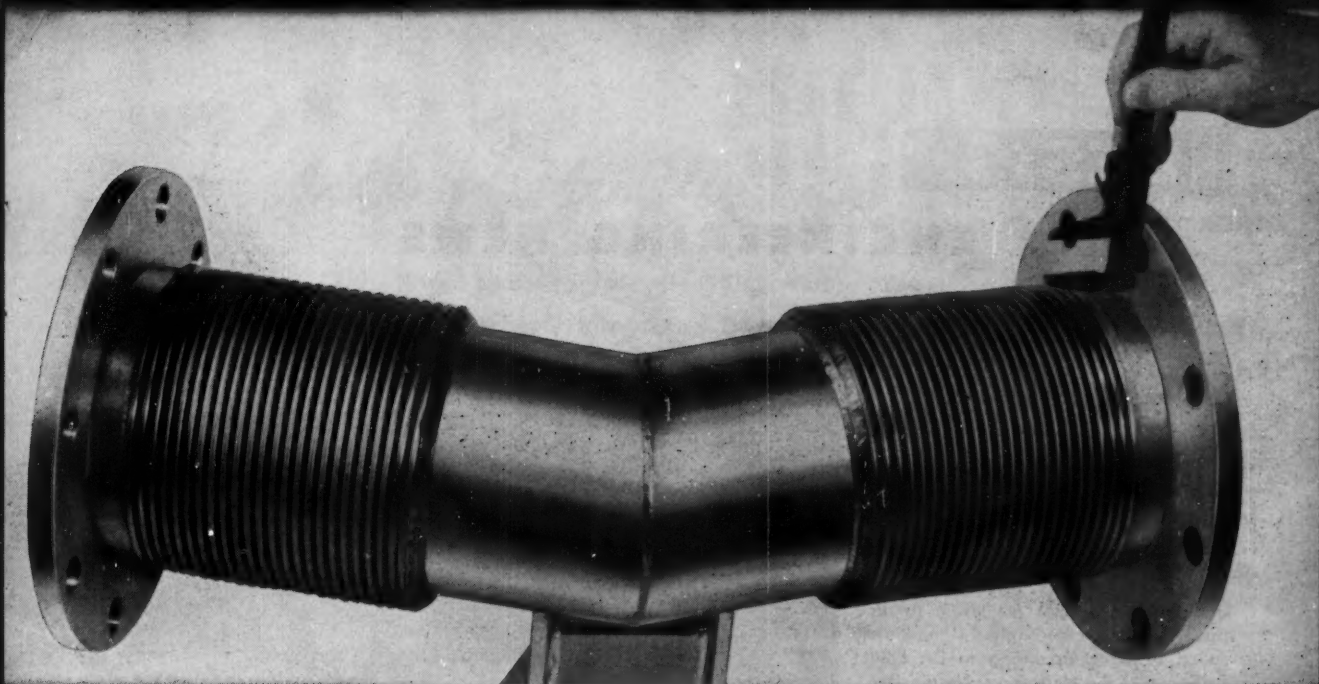
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## Expansion-joint tubing for big, tough jobs

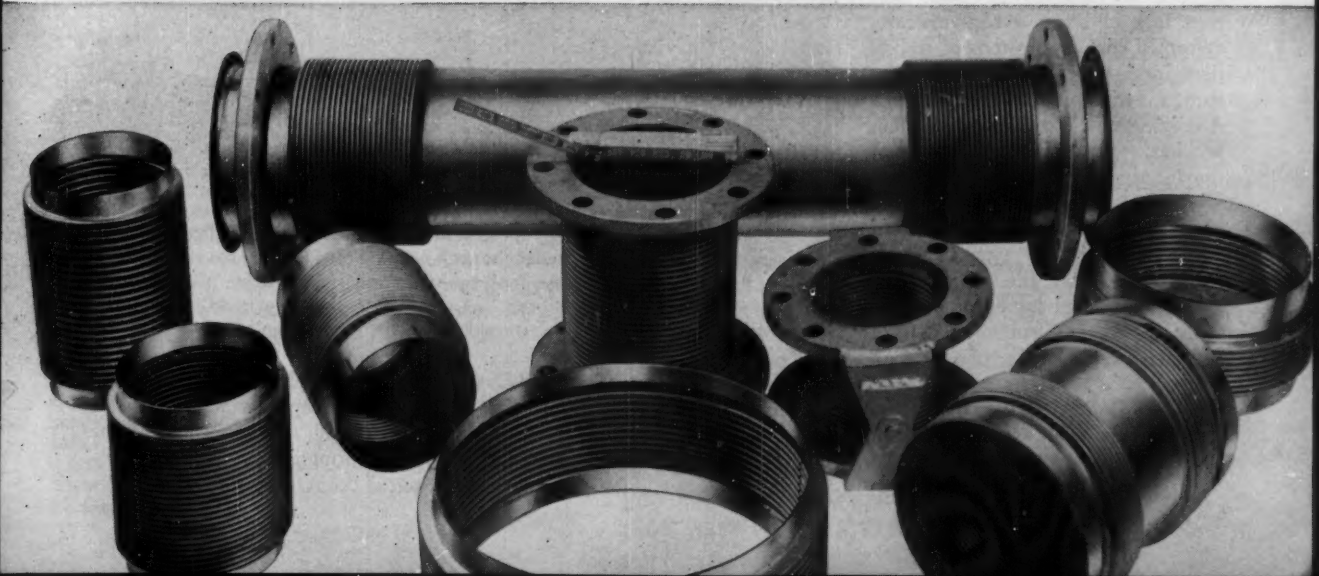
**New AX Tubing by Anaconda is available in Bronze, Stainless Steel, and other metals and alloys—from 4½" I.D. to 14" I.D.—to handle axial and lateral movement.**

Need to compensate for contraction of piping suddenly cooled to minus 300°F by a large volume of liquefied gas? Want a bulkhead seal that "gives" with hull movement? Do you need a special assembly like that above, which handles an offset and a combination of lateral and axial movement? Wherever you need large diameter tubing to take care of movement shown in drawing at left, or simple offset, write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

50128

# ANACONDA® METAL HOSE

Circle 406 on Page 19



## ENGINEERING NEWS

### Space Travel Threatened with 600-Trillion-Mile Limit

The "disintegration barrier," destructive effect of collision with microscopic dust particles in space, presents a new obstacle to interstellar travel. An adult would have to travel almost at the speed of light to reach—in his lifetime—stars more than 100 light years, or 600 trillion miles, away. Unfortunately, space vehicles are likely to disintegrate at a speed slightly under the speed of light, according to Dr. Elliot T. Benedikt of Northrop's Norair Div., Hawthorne, Calif. Destruction would be caused by absorption of large amounts of deceleration radiation emitted by electrons in the colliding dust particles—a large part of the mass of the electrons would be converted to energy. White spot (indicated by arrow) superimposed on the Andromeda galaxy represents an area comparable to one in space around the earth that might be explored during an adult's lifetime.

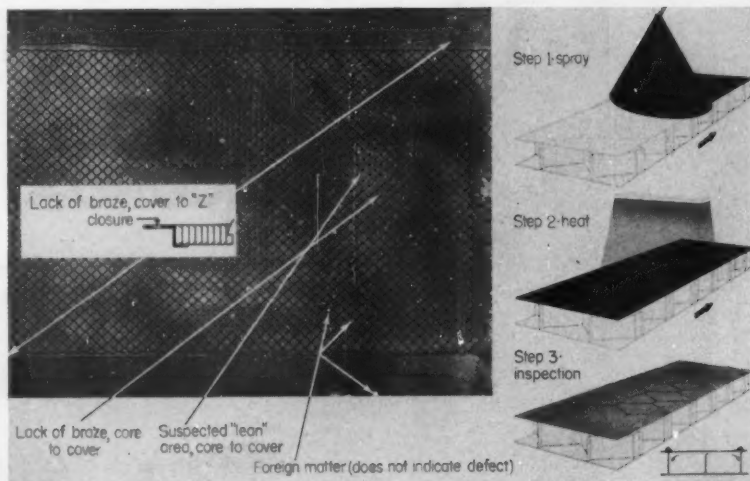


### Honeycomb Test Simulates Peek Inside the Panel

LOS ANGELES — Development of a quick, nondestructive test for flaws in honeycomb materials may lead aircraft and missile makers to take greater advantage of the high strength offered by sandwich panels.

The new Bondcheck system, developed by Magnaflux Corp., detects lack of braze, excessive braze, deformed core, indications of ribbon flow, and other irregularities. Accuracy is high; cost is relatively low. According to a company spokesman, previous test methods "often cost the industry as much as the actual fabrication of the panels." He also quoted an August, 1959, Stanford Research Institute report which pointed out that the difficulty of testing completed honeycomb panel other than by destruction has been a drawback in the use of sandwich material.

In the Bondcheck process, heat-sensitive fluid is sprayed on a panel, and a pattern appears when the



Defects inside a honeycomb panel are indicated by irregularities in pattern formed in Bondcheck Thermographic test. Automatic process (right) applies a heat-sensitive coating, then heats the panel with infra-red lamps. Dried immediately, the panel is available for inspection and photography, if a record is desired. Processing equipment can be adapted to handle curved, wedged, or extra-thick sections, as well as standard flat honeycomb panels.

panel's surface is heated. Fluid is repelled from warm areas but coalesces in cool spots. Core partitions act as heat sinks, causing the fluid

to flow to each area of good braze. No pattern appears where braze is lacking, and the pattern duplicates core deformation.

# ... Fluid Power

# news

**REPORT  
NO. 11,303  
SPEED—COST  
"BREAK-THRU"  
FOR GLASS  
PACKAGING**

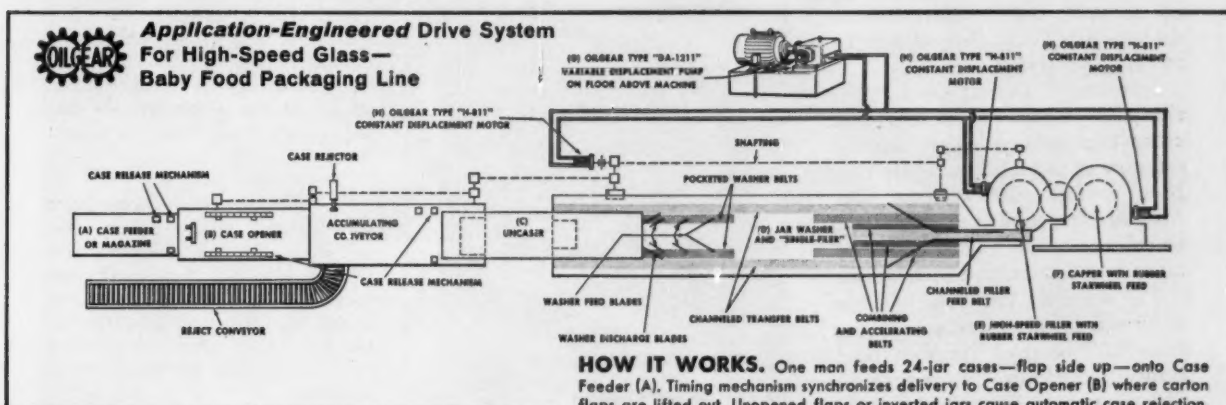
From Oilgear Application-Engineering Files

## HOW OILGEAR SYSTEMS on Gerber's Integrated Glass Lines BOOST OUTPUT—CUT COSTS

**USER:** Gerber Products Company, Fremont, Michigan; Rochester, New York; Oakland, California

**DATA:** To sharply reduce breakage, jam-ups, downtime, and labor costs in filling glass baby food jars at higher speeds, Gerber's Engineering Research Department developed the first fully integrated, high-speed machine for packaging foods in glass economically, under completely automatic control. *Drive Requirements for this multi-unit machine were outlined as follows:* 1. Complete synchronization of the seven integrated units through three drives—at the Uncaser, Filler, Capper. 2. Positive, precise, remote pneumatic

control of operating speed that is instantly, infinitely variable from very slow to top speed while the machine is running. 3. Controlled acceleration and deceleration to prevent jars from tipping and jamming, eliminates spillage, reduces machine strain. 4. Compact, for maximum work area. 5. Independent operation of Filler and Capper drives to facilitate cleaning. 6. Trouble-free, dependable, long-life operation, immune to frequent sanitary washdowns, fully enclosed to prevent food contamination.



**SOLUTION:** An Oilgear "Any-Speed" Drive, consisting of a Type "DA-1211" variable displacement pump and three Type "H-811" constant displacement motors—powers all elements of "The Gerber Integrated Glass Lines" to meet and exceed originally specified drive requirements. For maximum work area around the "Glass Line," prevention of possible food contamination, and use of an economical electric motor, the Oilgear "Power-Pak" is located on a different floor of the building. A compact control panel located at the Filler enables the operator to start, stop, jog, and instantly vary speed of the entire machine through an infinite range while the machine is running—thereby obtaining maximum efficiency for the consistency of the food being filled. The drive system automatically synchronizes the speed of all seven machine units. Operating speed ranges from 550 to 650 jars per minute—depending entirely upon the products being filled... an increase of up to 23% over former conventional glass packaging methods.

**GERBER REPORTS**—"The major advantages of this newly developed equipment are: less shock and scratching of jars, which reduces damage; substantially higher speeds; more thorough washing; lower maintenance cost and automatic control of all segments of the line."

Due to the smooth, cushioned application of power, even at higher speed, reduced glass damage and the resulting reduction in downtime, maintenance and labor costs with this Oilgear-powered, Gerber-designed machine, an expanded installation program of these "Integrated Glass Lines" is now under way at all Gerber plants.

**HOW IT WORKS.** One man feeds 24-jar cases—flap side up—onto Case Feeder (A). Timing mechanism synchronizes delivery to Case Opener (B) where carton flaps are lifted out. Unopened flaps or inverted jars cause automatic case rejection. Normal cases proceed to Uncaser (C) where the case and divider panels are pushed down and away from the jars. Uncaser deposits jars on transverse-channeled conveyor platens. Blades slide jars from channeled platens into pocketed belts which hold jars inverted through Washer (D). Jars are plowed from washer belt pockets to transverse-channeled combining and accelerating belts—moving 350 to 400 jars per minute... are then "shuffled" into the "Single-Filler"—550 to 650 jars per minute on a channeled belt to Filler (E). Rubber starwheels minimize breakage in feeding the 25-pocket Girdler Filler (E), and 16 twin-head Anchor-Hocking rotary Capper (F)... both custom-built for Gerber with center-to-center jar spacing for positive, smooth glass transfer between units. Smooth synchronization, cushioned acceleration and deceleration provided by the Oilgear Drive and Control System, combined with no jar-to-jar contact make possible the almost noiseless higher speeds and virtual elimination of glass damage... for if even a single jar or bottle is broken in food or pharmaceutical operations, a complete and costly shutdown, cleanup and inspection of the packaging line by quality control personnel is required.

**"PLUS"** features of this Oilgear Drive and Control System are: dual, automatic, built-in hydraulic and electric overload protection—stops the machine in event of jamming or malfunction... automatic hydro-dynamic braking... direct torque reading at the control panel... constant pressure and flood lubrication with continuous power fluid filtration... complete flexibility for location of drive and control components... fast, easy installation... standard drive and control components sealed against washdowns... lower power consumption—using only power in proportion to work performed. There are many more—but these alone should be sufficient proof why designers and builders of machinery are turning to Oilgear, and say... "for the lowest cost per year—it's OILGEAR!"

For similar practical solutions to YOUR linear or rotary Controlled Motion problems, call the factory-trained Oilgear Application-Engineer in your vicinity. Or write, stating your specific requirements, directly to...

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## Titanium, Columbium Hail Major Advances

### New Coatings Promise More and Varied Uses

CLEVELAND—The design stature of two modern metals is enhanced considerably by new developments from the Army's Detroit Arsenal and Navy's Naval Research Laboratories.

The Army's contribution is a vacuum metallizing process for producing titanium protective coatings on ferrous base metals. Detroit Arsenal's new process provides a nonporous film having excellent coverage and tenacity. Titanium metallized ferrous metals have satisfactorily passed the 200-hr salt-fog test as prescribed for corrosion resistant materials in Federal Specification QQ-M-151a.

According to Detroit Arsenal metallurgists, many components now using electroplated nickel coatings can now be protected more effectively by a metallized titanium film. Also, titanium-coated mild steel can be substituted for solid or clad titanium in many present applications.

The relatively thick titanium film is formed by means of evaporation from 0.05-in. thick tungsten boats heated electrically. A preliminary degassing of the base metal provides a sufficiently clean surface for receipt of the titanium vapor. No other surface conditioning is needed.

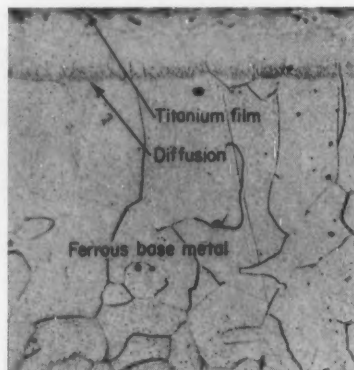
The Navy's contribution has to do with columbium . . . the metal considered most likely to succeed in the now popular 1800 to 2500 F range. At these temperatures, and when exposed to oxygen, columbium usually turns to powder, a trait it shares with the other refractory metals.

Navy research scientists have cured the powdering tendency with a brand-new self-healing coating. Called NZ-1 the coating uses ordinary grades of zinc as the starting material.

Although zinc ordinarily boils at 1680 F, it survives in this instance because of a peculiar alloying action. NRL scientists explain that the zinc is retained on the surface as a zinc-rich alloy of columbium. When the coating is exposed to air at high temperatures, zinc is released gradually from the alloy to

form a protecting layer of complex zinc-columbium oxide. This is the material that shields the metal from attack by oxygen.

Because NZ-1 is ductile and plastic at high temperatures, it seldom opens up when the base metal is deformed under load. Even if bare metal should be exposed, the self-healing action immediately repairs the defect. The coating is compatible with a wide variety of columbium alloys. Application is accomplished either by dipping the columbium in a molten zinc bath, by electroplating, or by vapor coating in a vacuum chamber.



Tough film of titanium is formed on ferrous base metals by Army's new vacuum metallizing process. The protective coating can range from 0.05 to 0.15 in. thick. After coating is applied, the composite film and base metal is vacuum diffused to eliminate porosity and increase coating adhesion.



Heating in air to 1800 F corroded uncoated columbium to crumbly white powder (bottom). The specimen (above) coated with Navy's new NZ-1 coating shows almost no oxidation effect.

## Topics

Golf on the level can be played by the enthusiast who acquires a newly patented putter. This stick, invented by two Massachusetts golfers, has a spirit level built into the shaft just below the handle. Using this level to check slope of the green between his ball and the cup, a golfer should be able to judge his putt accurately.

Beware of watches bearing strontium-90, warn the Atomic Energy Commission and the American Rolex Watch Corp., New York. AEC is attempting to recover watches, imported from Switzerland by Rolex or purchased abroad by Americans, which contain an excessive amount of radioactive strontium-90 in the luminescent markings. Watches involved are Rolex GMT-Master wrist watches, a special type of navigation timepiece which has a movable bezel around the dial to show any two time zones of the world at a given moment. Not all the watches of this type are dangerous, but Rolex wants to inspect them.

DC tourniquet stops hemorrhages with a small electric current. Experimental apparatus described by Ohmite Mfg. Co. consists of nine telephone batteries, an ammeter, and a rheostat. Heavy bleeding can often be stopped merely by inserting the electrode into the blood that is collecting.

Merger of woofers and tweeters has been accomplished by Dr. Amar G. Bose, assistant professor of electrical engineering at MIT. In Dr. Bose's instrument, a cluster of 22 small speakers is housed in a container shaped like one-eighth of a sphere having a 20-in. radius. It is designed for use in the corner of a room. Low notes cause vibration of the instrument's whole curved surface; high notes are reflected from the walls.

Internships and residencies in engineering, made necessary by the increasing complexity of the subject, are imminent, according to Prof. William G. Dow, chairman of the Dept. of Electrical Engineering at the University of Michigan. In a speech to a group of AIEE members, Professor Dow emphasized the importance of education at the graduate level. He said, "We're also extending our instructional resources to areas outside the campus itself and are trying to work out plans to make such off-campus graduate-level teaching more fully an integral part of the total program."



## MICRO SWITCH Precision Switches



### Precision switches to meet a wide variety of product design and plant use applications

MICRO SWITCH precision switches are important components in almost every type of electrically operated equipment—from delicate instruments to massive machine tools. They are installed on existing plant equipment to make operation safer, more automatic, and more productive. Shown here are but a few of the many thousands of MICRO SWITCH precision switch types which are famous throughout industry for utmost reliability, long-life, and precise operation.

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**Experience**—MICRO SWITCH is a pioneer in the manufacture of precision snap-action switches to meet a wide variety of applications.

**Quality**—MICRO SWITCH products are laboratory-tested from raw materials to the finished product. Absolute reliability and uniformity of performance is assured.

**Service**—Experienced MICRO SWITCH Field Engineering Service is available from branch

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**Savings**—Precise operation, long-life dependability, and freedom from maintenance of MICRO SWITCH products produce considerable savings of time and money.

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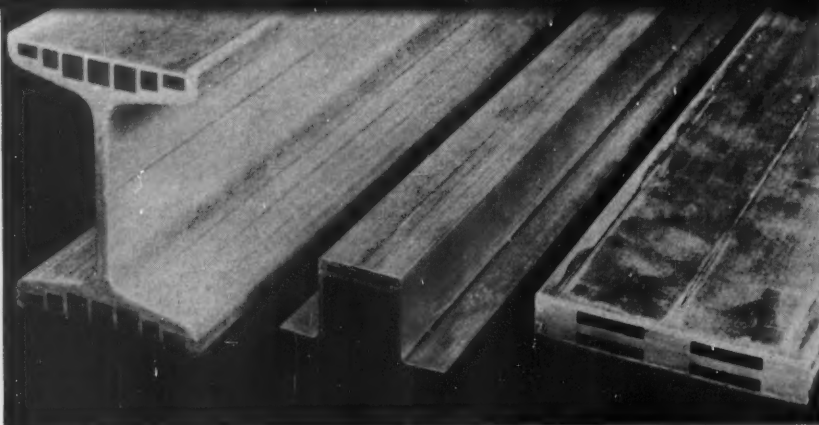
In Canada: Honeywell Controls Limited, Toronto 17, Ontario



# Honeywell

MICRO SWITCH Precision Switches

Old structural shapes in new "cellular" form effectively damp high-frequency vibration. Aluminum I-beam (left) contains 14 "steel-cell inserts;" the 1 x 1-in. channel contains a 1/16-in. steel insert; the 1/2 x 3-in. rectangular section contains four steel inserts. Viscoelastic damping medium at the interface of cell and insert absorbs dynamic energy when the beams flex under impressed vibration. Resonant response is thus drastically reduced.



## Built-In Damping

tranquilizes  
high-frequency vibration

NEW YORK—Turbojets and rockets have ridden roughshod over ordinary methods of vibration control. The shattering range of high frequencies set up by these space-age engines simply overpowers conventional isolating devices and structural designs.

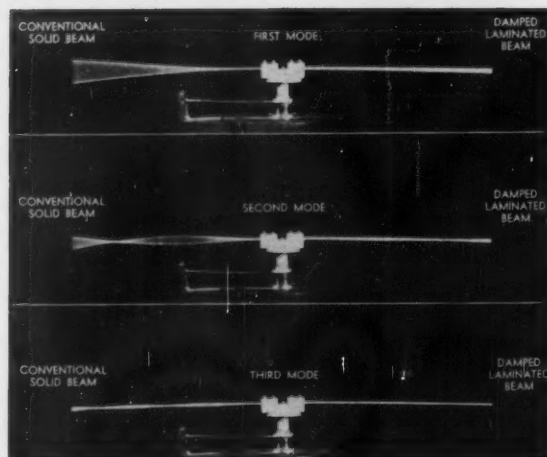
In searching for a solution to this critical problem, engineers at Barry Controls Inc., Watertown, Mass., have created some relatively new damping techniques. Largely theoretical, these concepts are based on the dynamic properties of laminated viscoelastic-damped structures, i.e., the structure is fabricated with a special viscoelastic damping medium (in the form of an adhesive) between laminates. Under flexural vibrations, the laminates slide relative to one another and produce a shearing of the viscoelastic medium. Resonant response is drastically reduced by energy dissipation in the shearing action.

While similar structures have been under study for some time, Barry engineers now claim two significant achievements:

- Their laminated structures are effective at wider frequencies ranges than any previous structures.
- They have developed a brand-new damping technique in the form of "cellular" construction.

The new cellular concept has been incorporated by Barry into standard I-beam, channel, and angle configurations. Outwardly, the beams and channels resemble their conventional counterparts, but they contain "longitudinal cells" throughout their length. Each cell contains an insert separated from the cell wall by the viscoelastic damping material.

Performance of these cellular structural members is impressive: Their usual resonant response ranges from 5 to 10 times the excitation vibration throughout the frequency range encountered in modern dynamic



### Built-in damping gives impressive results:

At 17-cps sinusoidal vibration input (top) conventional beam amplifies the vibration by a factor exceeding 100. Damped beam amplifies by factor of about 10.

At first harmonic frequency of 105 cps (center) vibration amplification of conventional beam exceeds 100, while that of damped beam is approximately 3.

At second harmonic, 300 cps (bottom) the damped beam appears stationary, while excitation of the undamped beam is still visibly apparent. Actually, amplification of the conventional beam is 50 times that of the damped beam.

environments. This is in sharp contrast to conventional structures, where the impressed vibration is amplified some 60 to 300 times, depending on the material and the vibration input. Even when formed into small riveted or welded structures, conventional materials amplify vibrations from 30 to 100 times at resonance.

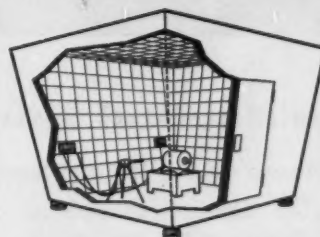
A viscoelastic damped member or structure has slightly less load carrying capacity than a conventional member of the same material and cross section. But because many designs are based on dynamic stress level, it is likely that the new materials will not require an over-all increase in weight or cross section.

According to Barry engineers, use of their new Rigidamp materials and techniques are not limited to a narrow range of frequency; by temperature variations; or by size and materials involved. Initial use is expected in the electronic, missile, and aircraft industries, because "that's where the big need is. But there is no reason why this construction cannot be applied to any type of structure, large or small, if the vibration problem is sufficiently extreme to warrant it."

News Report, "Designing Damping into Laminated Structures," starts on Page 24.



## PRODUCT INFORMATION



N/D sound booth for analysis of electric motor noise, mounted on springs and constructed with non-parallel walls, assures manufacturers a scientific solution to electric motor noise problems. Motors are tested with special electronic sound evaluation equipment.

## How Minimizes Electric Motor Noise!

In New Departure's full-time noise analysis program, a unique sound booth and special electronic sound level equipment are used to pinpoint and evaluate electric motor noise. Inside the booth, a condenser microphone picks up air-borne noise from the running motor. Outside, the signal is electronically registered and recorded.

By changing one variable at a time, such as bearing or mounting design, or lubricant, N/D engineers are able to select the proper com-

bination that results in the quietest motor operation. That's why you'll find New Departure precision ball bearings specified for electric motors to be used in quality home appliances, instruments, fans, hand tools and other applications . . . for greater consumer sales appeal.

If you have an electric motor noise problem, contact the N/D Sales Engineer in your area. For additional information call or write New Departure Division, General Motors Corporation, Bristol, Connecticut.



**NEW DEPARTURE**  
**BALL BEARINGS**  
*proved reliability you can build around*

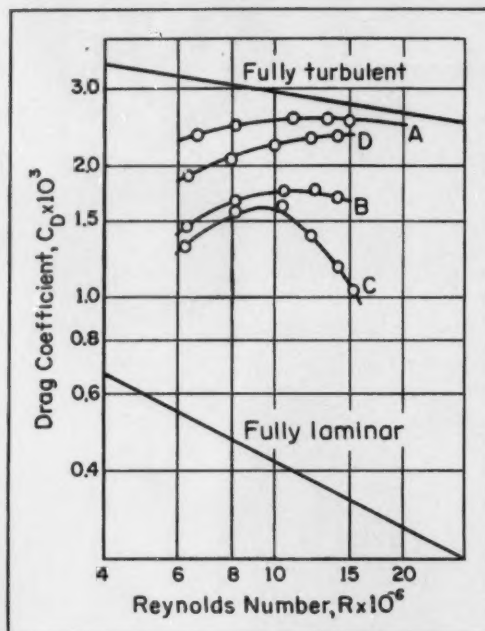
Flow is changed from turbulent to near laminar, depending on skin damping and stiffness. Test rig (below) shows the 2.5-in. cylindrical model (uncoated in the picture) which was towed underwater at speed of 30 knots.

Normal performance **A** is a benchmark, obtained from model with its surface glossed and rigid (uncoated). Surface is almost fully turbulent at maximum Reynolds Number ( $R = 15 \times 10^6$ ).

Better performance **B**, a 35 per cent drag reduction, is chalked up by coated model having 1600 lb/cu in. stiffness.

Best performance **C**, a 59 per cent drag reduction, is obtained when coating incorporates 800 lb/cu in. stiffness.

Performance fall-off **D**, only 10 per cent drag reduction, occurs as stiffness is decreased to 600 lb/cu in.



## New Nautical Skin Will Multiply Marine Speeds

Unusual Coating May also Improve Flow in Hydraulic Components

NEW YORK—Dramatic advances in water transportation may result from the development of a thin rubber coating—copied from the porpoise—that promises a vast increase in the speed of submarines and other marine vessels.

Dr. Max O. Kramer, vice president, Coleman-Kramer, Inc., Los Angeles, is the inventor of the coating. He is also a leading authority on the theory of antiturbulence (boundary layer stabilization by distributed damping) which is the key to the new nautical skin.

United States Rubber Co. is working with Coleman-Kramer on the project and is equally enthusiastic about its potential. U. S. Rubber technologists have already developed coatings which have reduced drag by about 50 per cent on underwater measuring devices.

Vice Adm. Charles B. Momsen, retired Naval submarine expert and co-developer of the Momsen lung escape apparatus, believes that submarine speeds of 60 knots (about 70 mph) would be possible with the development of a successful submarine "skin." With further improvement in powerplants, he predicts 180-knot (about 207-mph)

speeds for "underwater objects."

Larger surface vessels such as passenger liners are less likely to benefit from the coating because they generate large bow waves which pose different drag problems.

Dr. W. E. Cake, vice president of U. S. Rubber, says, "Theoretically, boundary layer stabilization can have an effect on anything that moves on or through water, anything that moves through air, or any kind of pipe or pipeline for moving liquids or gases."

U. S. Rubber will produce the drag-reducing coating under the trademark "Lamiflow." The coating consists of a thin layer of rubber supported by a multitude of tiny rubber pillars. Inter-connecting channels between the pillars contain a freely flowing viscous liquid (silicone-base oil). The channels face the surface of the object. The outside, or water side, of the coating is smooth. The channels give the coating flexibility, and the liquid provides the necessary damping to suppress potential turbulence. The resilient, energy-absorbing coating delays boundary layer transition from laminar to turbulent, and thus reduces drag.

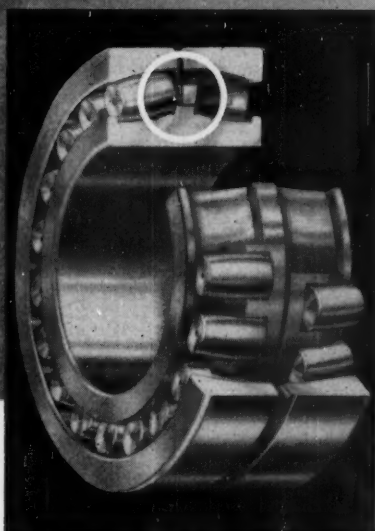
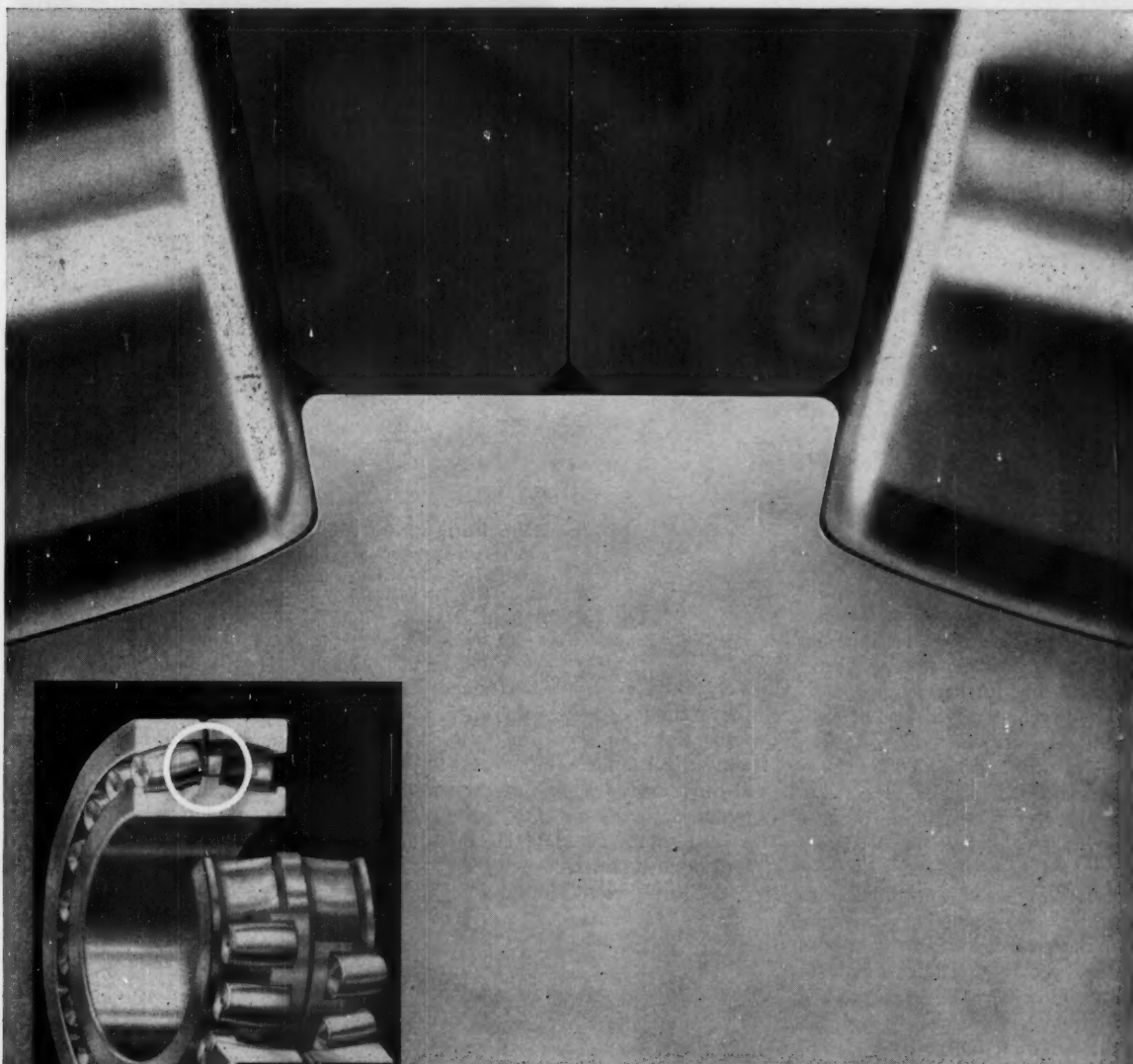
Dr. Max O. Kramer, the man responsible for the neo-porpoise skin, is the former head of the Aerodynamic Institute of the German Research Center for Aeronautics. He first observed porpoises on a voyage from Europe to the U. S. and calculated that a porpoise must have only one-tenth the drag normally expected from an animal of its size and shape.

Dr. Kramer logically anticipated that drag-producing turbulence did



not form along the porpoise's body ... in fact, the porpoise must have solved the unporpoise-like problem of "boundary layer stabilization by distributed damping."

To make a long story short, Dr. Kramer obtained some porpoise skin for experimental purposes. And he discovered, naturally, that the porpoise is completely covered with a 1/16 in. "hydraulic skin" that is elastic and ducted ... just like the porpoise skin now made by U. S. Rubber.



**TORRINGTON**  
Spherical Roller Bearings Offer:

- inherent self-alignment
- conformity of rollers to raceways
- integral center guide flange for stability
- positive roller guidance
- land-riding bronze cages
- maximum radial and thrust capacity
- controlled internal clearance
- electronically selected rollers
- even load distribution
- long, dependable service life

Send for new Torrington  
Spherical Roller Bearing Catalog #258.

## Keystone of Stability!

The integral center guide flange of the *Torrington* Spherical Roller Bearing provides *positive* roller guidance—the one best way to insure operating stability under radial and thrust loads.

Center guide flange surfaces and roller ends are ground to a common spherical radius. The asymmetrical roller seeks this flange under load, bearing lightly but constantly against it. Roller wobble and skewing are eliminated, and stress concentrations leading to early failure are avoided. Bearing operation is cooler, quieter and smoother.

The integral guide flange is adapted from the same principle used in the design of Torrington Tapered Roller Bearings. It is an engineering refinement, based on experience in all types of applications, that insures outstanding performance in your equipment. **The Torrington Company, South Bend 21, Ind.—and Torrington, Conn.**

## **TORRINGTON BEARINGS**

*Every Basic Type of Anti-friction Bearing*

**SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • NEEDLE • BALL • NEEDLE ROLLERS • THRUST**

Researchers are finding ways to use the odd happenings in the ultracold, and designers may soon be coming up with many types of new devices. First of these seems likely to be . . .

## The Cryo Gyro

CRYOGENIC gyroscope now under development operates near absolute zero. Magnetic fields both float and spin a superconducting sphere at high speed in a vacuum. Electrical and frictional losses are almost zero, and once the sphere is set in motion, it rotates practically forever. Early experiments have demonstrated the device is feasible and the Army's Ballistic Missile Agency is sponsoring further work.

The gyro, conceived by Dr. T. A. Buchhold of General Electric's General Engineering Laboratory, Schenectady, N. Y., is expected to prove many times more accurate than conventional gyros because it eliminates general causes of gyro error. Elimination of mechanical bearings, and reduction of friction and electrical losses both permit increased accuracy. Dimensional stability induced by the well-regulated cryogenic temperature should also make it more reliable.

At temperatures a few degrees above absolute zero, about 20 metals and many compounds and alloys have no electrical resistance—they become superconductors. A current trapped in superconductive coil circulates almost forever (unless deliberately interrupted) to produce a magnetic field that stays constant. The gyro uses this frozen field to float its superconductive rotor.

A magnetic field of less than a critical field strength cannot penetrate a superconductor. Rather, the superconductor acts as magnetic insulation, repelling and shaping the field around itself. But just as the superconductor repels the field, so also does the field repel the superconductor, i.e., it tends to force the superconductor away. The gyro's rotor spins due to torque produced by a second magnetic field.

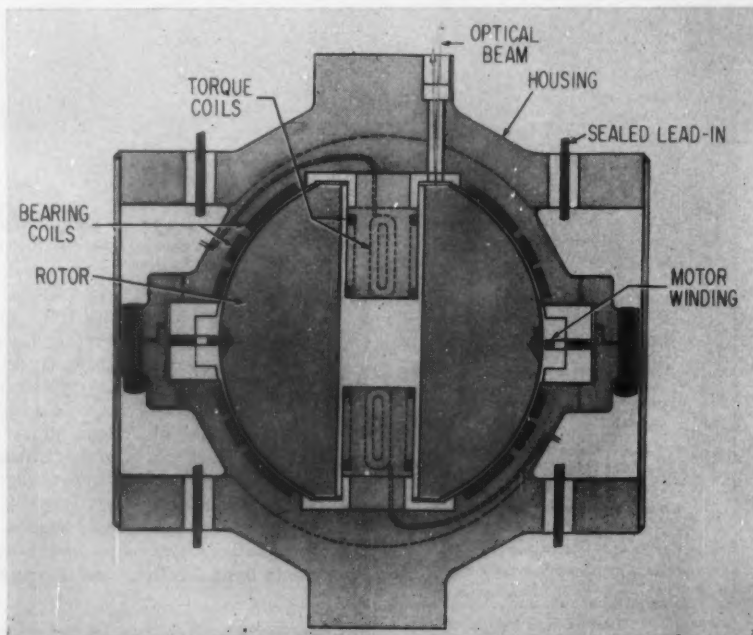


**Golfball-size** sphere will rotate at high speed in GE's new superaccurate gyro. The sphere, suspended in a vacuum by a magnetic field, takes advantage of the strange behavior of metals at temperatures near absolute zero. Once it's started in motion, it should spin practically forever.

Very little power is consumed by the second coil because once the rotor is up to speed its losses are almost zero. General Electric has already operated an experimental motor designed on these principles at a constant speed of 20,000 rpm for extended periods.

At the present time, supercon-

ductivity requires temperatures so low that only liquid helium is cold enough to produce them. Helium liquefies at  $-456^{\circ}\text{F}$  ( $-460^{\circ}\text{F}$  is absolute zero). If research can come up with new materials that become superconducting at higher temperatures, more applications will become practical. General Electric is experi-

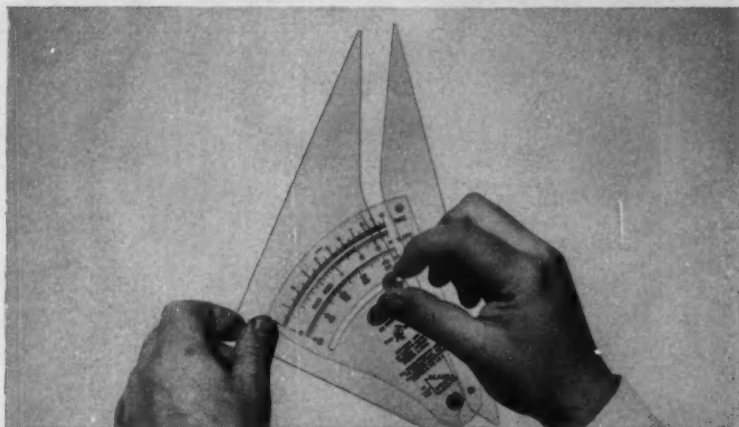


**Magnetic fields** do the work. While one field is holding the superconductive gyro's rotor in position, the field generated by the torque coils is rotating it. Current, trapped in the superconductive bearing coils, recirculates practically forever. Electrical and friction losses are reduced almost to zero.

menting with many other cryogenic devices. Among them, the following are either under study or appear worthy of study:

- Since superconductors shape a magnetic field, magnetic lenses might be designed by flux shaping. These lenses could have reduced errors and greater resolving power than ever before possible. An electron microscope might be designed to see targets as small as atoms.
- A superconductive coil with a trapped current could make a very accurate standard of reference. Any current to be measured would need only have its magnetic field compared with that of the standard.
- With proper coil arrangement and a frozen-in flux, a superconductive bearing can be suspended in space. High bearing stiffness can be obtained and mechanical wear eliminated. Such a bearing would work in a vacuum.
- A cylindrical or spherical superconductor can be turned by a rotating flux produced by a polyphase winding. Such a motor would be almost 100 per cent efficient (ignoring losses in the power supply).
- A superconductive dc to ac amplifier could be built having no zero drift and no noise. A signal source would feed a control current into a lossless superconductive control winding. The flux from this winding would be chopped by a rotating superconductive disc (consisting of segments which act as magnetic insulation). In a second winding, an ac voltage and output power would be produced.
- All basic types of computer circuits can be built from combinations of cryotrons—tiny and relatively simple devices that consist of gate wires influenced by control wires. Superconductors become resistive when they are exposed to a magnetic field of more than a certain field strength. Current in the control wire could destroy the superconductivity of the gate wire, making a two-position switch.
- Resonant cavities with very little damping ( $Q$  numbers in the millions) are possible because superconductors do have a very small surface resistance at high frequencies (above 10 megacycles). Frequency-standard oscillators using such cavities might be as accurate as an atomic clock.

## DRAFTING TRENDS



This versatile, easy-to-handle, adjustable triangle is made of yellow-tinted optical-grade acrylic plastic. A clean-cut oval track fitted with metal knurled knob assures ease of operation and lasting tight fit.

### New combination protractor-triangle speeds up drafting

Architects, Engineers, Builders, Field Surveyors, Mathematicians—anyone who develops solutions to measurement problems indirectly to determine a wanted measurement graphically or mathematically—will find the Trig-Matk Adjustable Triangle a handy tool. It eliminates much of the graphic work necessary in estimating results or in checking for correct answers.

#### Versatility with accuracy

Basically the new Post Trig-Matk Adjustable Triangle is a mathematician's tool—accurate to three decimal places.

It combines the functions of a protractor and a triangle into a simple unit, with two fundamental trigonometric relationships of a right triangle. The Trig-Matk provides accuracy within 0.1% in problems dealing with any of the six trigonometric ratios of the sides of a right triangle.

The adjustable protractor has three sets of graduations. One set is graduated in half degrees, labeled *Degrees*, and permits the use of the Trig-Matk as a protractor setting for determining any angle from 0 to 90 degrees.

The second set of graduations, labeled *Slope*, shows directly the *Secant* trigonometric ratio of the angle indicated on the degree scale. The third scale, labeled *Rise*, indicates directly the *Tangent* trigonometric ratio shown on the degree scale.

#### Examples

This new tool has a host of drafting and engineering applications. Highway designers find the Trig-Matk very useful when making cross sections of roadways at ground level or below. By



An indicated angle of 40 degrees on the Trig-Matk (1589) shows directly that the Rise is 8.4 to the base of 10.

setting the *Slope* scale to the degree desired, road-curve grades are automatically determined. The protractor can be used to determine the angle of highway ingress and egress lanes.

Structural Engineers will find the Trig-Matk Adjustable Triangle a simple tool, eliminating the use of both a scale and individual triangles. In addition to the time saved, many of the errors usually associated with the older method are avoided. The Trig-Matk design eliminates the need of frequent reference to handbooks for information on various bevels.

#### Two Bases

The Trig-Matk No. 1589-12 has a 12" base scale for handy calculation in terms of feet and inches. Number 1589-10 has a metric base scale of 10.

Keep posted on all the latest trends in drafting. Consult your local Post dealer, or write to Frederick Post Co., 3652 North Avondale Ave., Chicago 18, Ill.



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ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE



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At your request, our gear engineers would be pleased to describe this process in greater detail and to explain, as well, what our recently expanded facilities can mean in terms of this pledge: "DOUBLE DIAMOND Gears offer the advantages of lower installed cost and economical and dependable service on the job...gears that do credit to your product and reputation."

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GEARS FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS  
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# Reader Information Service

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## USE A YELLOW CARD for More Information...

**CIRCLE ITEM NUMBERS**—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

**EDITORIAL CLIPSHEETS**—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
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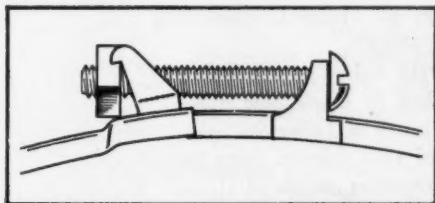
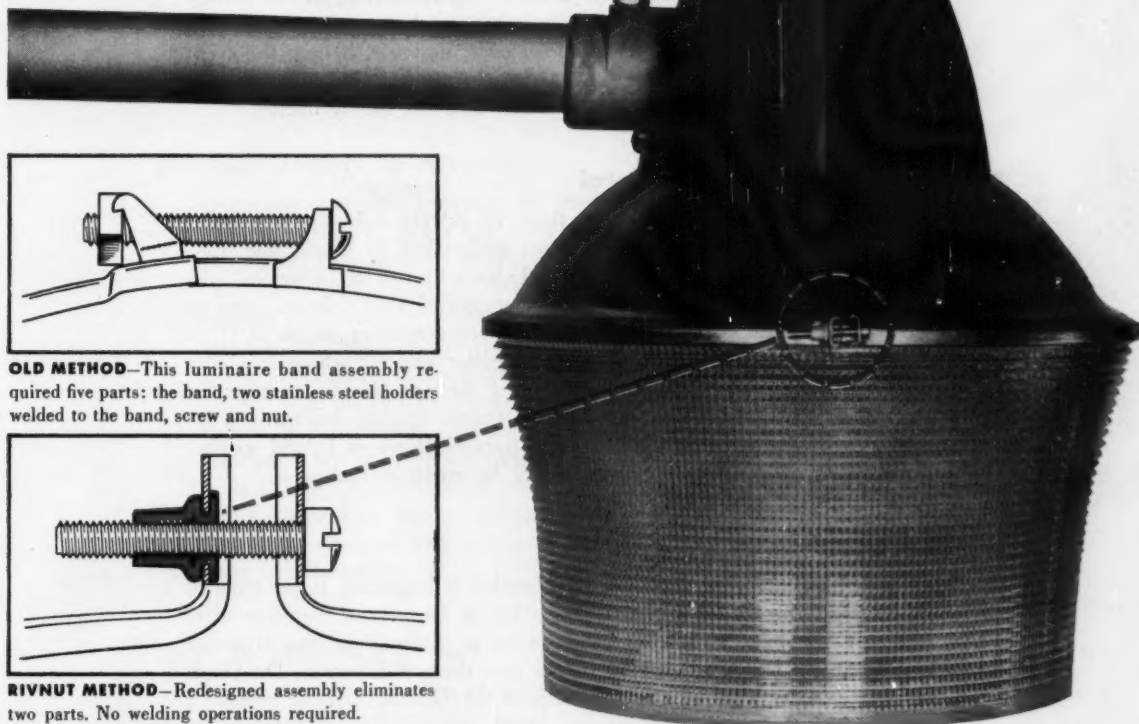
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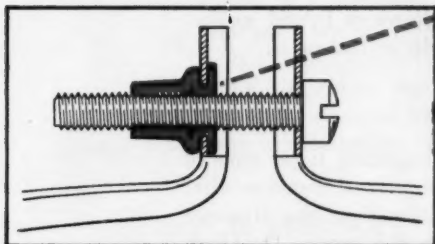


**B.F. Goodrich**

## Improved fastening with **RIVNUTS®** cuts costs on new luminaire



**OLD METHOD**—This luminaire band assembly required five parts: the band, two stainless steel holders welded to the band, screw and nut.



**RIVNUT METHOD**—Redesigned assembly eliminates two parts. No welding operations required.

The manufacturer of this outdoor lighting luminaire, Line Material Industries, McGraw-Edison Company, reports "considerable cost savings" since redesigning the luminaire holding band for RIVNUT fastening.

Five separate spot welds were eliminated, along with two parts. The RIVNUT is strong and secure. And unlike the old method, there's no loose nut to be dropped.

RIVNUTS are the only one-piece blind rivets with internal threads. They can be installed by one person, from one side of the work, in a few seconds with a heading tool. If you'd like recommendations on a specific fastening problem, please send a print of your part.

**You can improve fastening in sheet metal, tubing, tanks with RIVNUTS**

New data booklet describes principle, typical applications of RIVNUTS, lists size and tool data. For free copy write Dep. MD-2, B.F. Goodrich Aviation Products, a division of The B.F. Goodrich Company, Akron, Ohio.



# B.F. Goodrich *Rivnuts*

### **appliance maker washes out the annual model change**

"Growing consumer reaction against the artificiality and economic waste inherent in annual model changes that do not improve [product] usefulness" has prompted American Motors' Kelvinator (appliance) Div. to abandon the practice. From here on, "we will introduce new products and models only when they are ready for the market," according to B. A. Chapman, Kelvinator's general manager. This unlikely phenomenon, happening in the fiercely competitive appliance field, has been branded as almost un-American by some industry sources. Foes of style obsolescence, however, hailing the event as a major victory, point out that change for the sake of change has helped make the appliance repairman more familiar than the family doctor.

### **salaries: federal vs. nonfederal**

Comparing government pay rates to those of private industry, a popular pastime among federal employees, has been undertaken by Uncle Sam himself. Interviewers from the U. S. Dept. of Labor's Bureau of Labor Statistics are seeking information from salary administrators of 1400 selected firms in 60 metropolitan areas. Questions asked of this representative sample of U. S. industry concern engineers and other white-collar workers whose jobs correspond to Classification Act occupations GS-1 through GS-15. Investigation will cover six job levels, approximately from trainee through executive as far as engineers are concerned, which closely parallel levels of federal service. Announcement of the survey's findings will be made in December.

### **super area-rule?**

The big fight shaping up over the B-70 bomber is beginning to jar some of the secrecy off the project. Latest design tidbit to be released concerns what is probably the most significant achievement in flight since the area-rule concept pushed Convair's F-102 jet fighter past the sound barrier. Dr. Hugh Dryden, former director of the now superseded NACA, first mentioned a major B-70 breakthrough to Congress a year ago, by announcing that the craft would fly supersonically during its entire mission. All current aircraft, including the Mach-2 B-58, cruise subsonically and make only a brief supersonic dash (at tremendous fuel expenditure) over the target area. Apparent reason for the B-70s big performance superiority is aerodynamic—i.e., utilization of a highly refined area-rule design.

### **simple test predicts metal cracking**

Less time, lower cost, and use of a much smaller test sample are advantages of a new metallurgical test developed by Dr. F. C. Hull of the Westinghouse Research Lab. The test is for hot cracking, a common weakness in stainless steels and other alloys. Metals suffering from this weakness crack under heat and stress of welding, or tear when a casting freezes out from the molten state. Previously, testing to predict susceptibility to hot cracking involved a number of operations, a sample weighing 100 lb or more, and complicated examination—all of which took weeks or months of time and cost hundreds or thousands of dollars. Dr. Hull's "cast tear pin" test, completed in minutes, predicts an alloy's behavior on the basis of how a small cast pin tears as it cools in the mold. In six months he has studied more than 800 samples of alloys and has used only 40 lb of metal.

### **N.E.—between M.S. and Ph. D**

Professional engineers desiring to practice nuclear engineering, but who don't require a doctorate, can enroll in Columbia University's school of engineering beginning next fall for work on an N.E. degree. Donald Barr, assistant to Columbia's dean of engineering, describes the new academic rating as "more advanced than an M.S., but less rigorous than a doctorate." He said the degree requires 30 points of courses beyond the M.S. degree, or 60 points of courses if the candidate merely has a B.S. The N.E. does not require a thesis if the candidate submitted one for his Master's, but comprehensive examinations will be required of all candidates.

### **printed circuits in reverse**

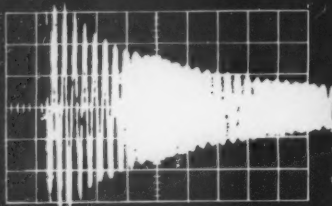
Generally accepted technique for making printed circuits is to start with the circuit board, solder the components on, then pot the whole assembly in plastic, if necessary. Scientists at MIT's Lincoln Laboratory have developed a simpler way—by reversing the usual technique. They start by arranging the various transistors, resistors, and capacitors in a three-dimensional pattern, and then encase the components in plastic. The six sides of the plastic block are milled off, leaving only the ends of the component leads exposed. The entire unit is copper plated to connect the leads, and unwanted copper is etched away, leaving the final circuit. For very complex circuits, additional layers of wiring can be plated on by merely coating each layer with plastic. Advantages of the new technique: Heat-sensitive transistors and diodes are not exposed to high soldering temperatures; copper connections give lower electrical resistance than soldered connections and will stand much more heat in service.

### **heat to electricity (ac)**

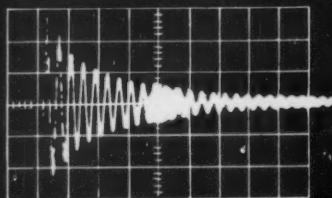
First successful conversion of heat directly into alternating current in "significant amounts," without the use of rotating machinery or dc-to-ac converters, is reported by General Dynamics Corp. Scientists at the Corporation's John Jay Hopkins Laboratory for Pure and Applied Science used a high-temperature cesium cell converter to produce "sufficient alternating current to illuminate a series of small light bulbs." The development promises to be highly important in converting heat from nuclear reactors into alternating current without the need of steam boilers, turbines, or generators.

### **the defense effort: fighting paper with film**

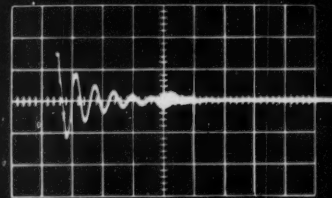
The military establishment spends \$1.5 billion annually for engineering drawings . . . another half billion or more for reproduction . . . receives annually 6 million new and revised drawings . . . maintains a file of 50 million drawings . . . distributes one billion prints . . . and is understandably in danger of being swamped by the whole process. One of the first steps toward relieving the situation will be the adoption of microfilm techniques. Defense Dept. expects that within the next three years, 80 to 90 per cent of new engineering data will operate from a microfilm base. When this is accomplished the Department wants "fully automatic equipment with speeds approaching those of present day digital computers and with the capability to store, retrieve, and reproduce engineering data in one continuous operation."



6061-T6 Aluminum



KIA Magnesium



Laminated ZE-10 Magnesium

## News Report:

# DESIGNING DAMPING INTO LAMINATED STRUCTURES

MINIATURIZATION and the continuing battle against weight are forcing significant changes in the art of packaging electronic equipment. Old design methods for controlling vibration in sheet-metal chassis structures don't always work in the close quarters and rugged environments of manned and unmanned aircraft and missiles.

Large resonant amplifications in primary and secondary structures (or in the electronic components themselves) are often the cause of low equipment reliability, short component life, and metal failure due to fatigue. Conventionally, the accepted remedy has been to reinforce structures so as to push natural frequencies up beyond normal operating ranges. To cut resonant amplification in individual components and smaller subpackages, designers have decoupled elements with shock mounts or other isolation devices.

Where such techniques are impractical, new approaches to the problem—built around the use of high-damping materials and lami-

nated structures—are pointing the way toward lighter chassis and improved protection for sensitive components. The concept is still in its infancy. This is a report on some early results.

### The Composites Look Best

Every material has inherent damping to some degree. Although usually considered negligible, this is the property that limits resonant amplification to a finite value by dissipating energy as heat.

Conventional criteria usually satisfy static-load requirements for electronic-package design. However, in many instances, conventional sheet-metal structures and standard shapes fail suddenly because of shock loads or continuous vibration at or near resonance. One method of eliminating or reducing the possibility of such failures is to increase the damping capacity of the structure. This can be done by substituting a single material known to have higher inherent damping properties, or by using a multi-layer composite—often, one made up of

a visco-elastic adhesive sandwiched between two or more metal sheets to absorb vibrational energy in shear.

The Sanders Associates' program to evaluate material damping properties was divided into two phases: 1. An impact test, in which a 1/2-in. diam ball was allowed to fall on the end of a clamped beam (Fig. 1). 2. A sustained, self-excited, reversed-stress test employing an MB exciter. A cantilever beam was the specimen in both phases.

**Damping Under Impact Excitation:** Oscilloscope traces across the top of this page compare magnitudes of energy absorption by cantilever beams that were shocked and allowed to return to rest. Obviously, the inherent damping in 6061-T6 aluminum (left-hand trace) is negligible, but is still measurable; the center trace shows that KIA magnesium possesses considerable damping for a solid material.

The really significant damping property is demonstrated by the laminated ZE-10 magnesium struc-

Damping . . . in a material or in a structure . . . is the checkrein that keeps amplitudes this side of infinity when resonance occurs. Here's a new technique for putting this useful property to work.

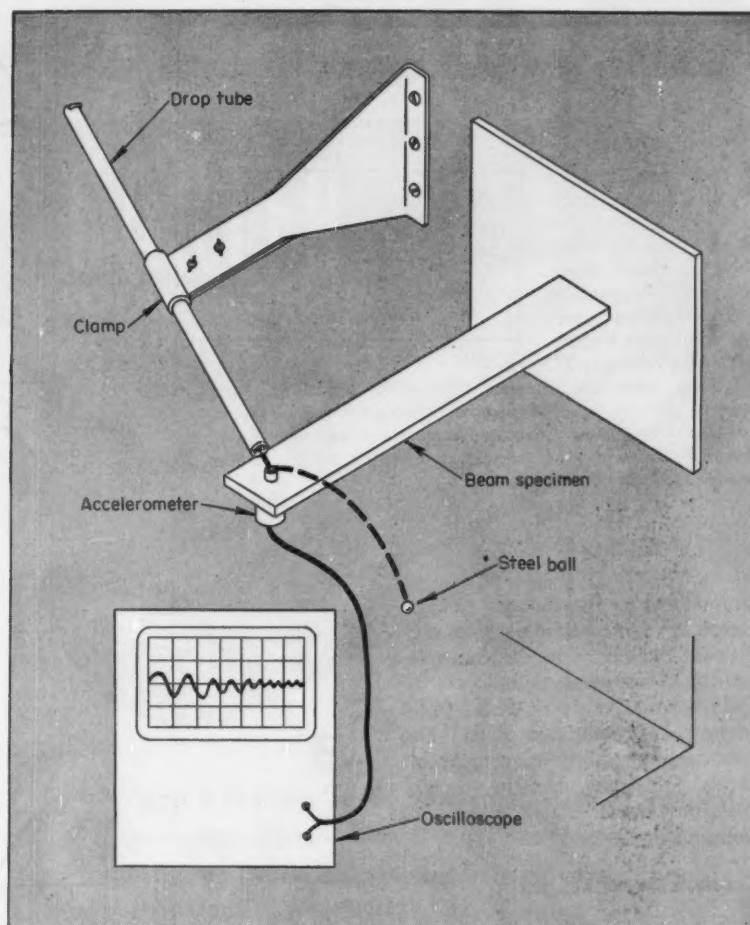
**HAROLD ROSEN**  
and  
**EUGENE D. VEILLEUX**  
Sanders Associates Inc.  
Nashua, N. H.

ture (right-hand trace). Energy absorption is much higher than that exhibited by the highly damped, solid-magnesium beam. High energy absorption of this laminated specimen is attributed to shear occurring in the visco-elastic material employed as the bonding agent.

**Damping Under Steady Excitation:** Natural frequencies of specimens checked under sustained vibration were found by sweeping the exciter through its range. Natural frequency of the beam was changed by varying beam length. Input and output readings were obtained through an accelerometer pick-up.

Test results (Fig. 2) show that the aluminum alloys amplify and transmit input loads to a much greater degree than either the magnesium alloy or the laminated structures. Furthermore, in laminated beam samples (6061-T6 and ZE-10), transmissibility\* depends on

\*Transmissibility is the ratio of output acceleration to input acceleration at any frequency. At resonant conditions, the driving frequency equals the natural frequency of the system.



**1** Controlled impact for the cantilever-beam test specimen was generated by this simple test setup. The steel ball (1/2-in. diam), rolling down the drop tube, initiated beam vibration. Time history of the decay was recorded by the accelerometer-oscilloscope instrumentation (see scope traces at top of facing page).

the type of visco-elastic material used and not on the structure material. This is readily apparent, since transmissibilities plotted for both laminated beams fall approximately in the same range. For a given adhesive, therefore, most chassis materials in common use will produce nearly equal transmissibility levels.

It should be noted that transmissibility values given here are empirical values for given cantilever-beam samples with a specific end condition. Data should not be interpreted as representing transmissibility for these materials under all conditions. Results are presented only to allow comparison of transmissibilities for the various materials and laminates. Additional factors affecting total damping energy with-

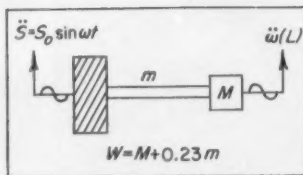
in a system include: 1. Support conditions. 2. Type of loading applied. 3. Frequency of stress reversal. 4. Thickness of visco-elastic material.

#### Missile Case History

An actual application of the laminated-material concept was in the design of a circular bulkhead for a missile. Forming part of a radio-transmitter package, the bulkhead is circular and is mounted to the missile frame at three or four points. Space limitations ruled out the use of conventional isolation mounts.

Results of tests on solid and laminated bulkheads and bulkhead mounts are plotted in Fig. 3. Obviously, the worst condition (highest transmissibility) occurs when the solid plate is mounted on solid mounts. Increasing the number of

**2** Sustained, reversed-stress excitation of cantilever beams gave these transmissibility values for solid aluminum, solid magnesium, and laminated specimens. Resonant frequencies of the beams (1.375 x 0.25-in. cross sections) were adjusted by adjusting beam length. Nearly equal transmissibilities exhibited by laminated aluminum and laminated magnesium beams are evidence that the visco-elastic layer, not the metal, is the energy-dissipating medium.



laminations in the mounts (an increase in shear surfaces) gives significant reductions in the transmissibility of the solid plate.

The other approach (solid mounts and laminated plates) also cuts transmissibility to comparable levels. Obviously, benefits are significant whether plates, mounts, or both are laminated.

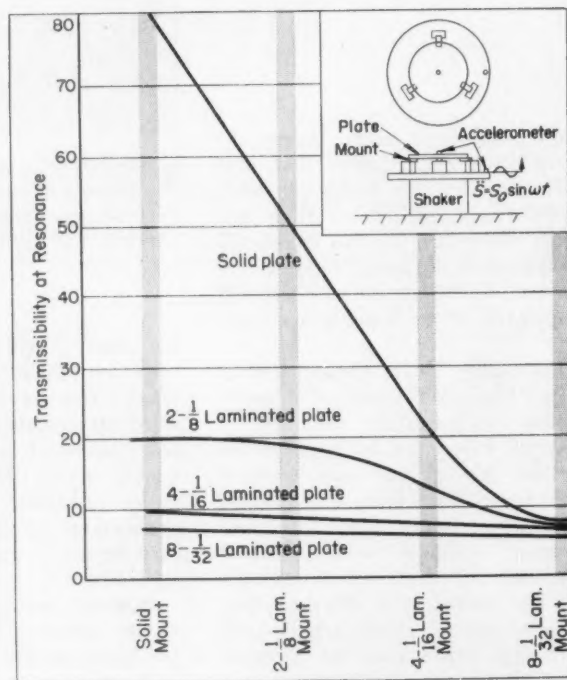
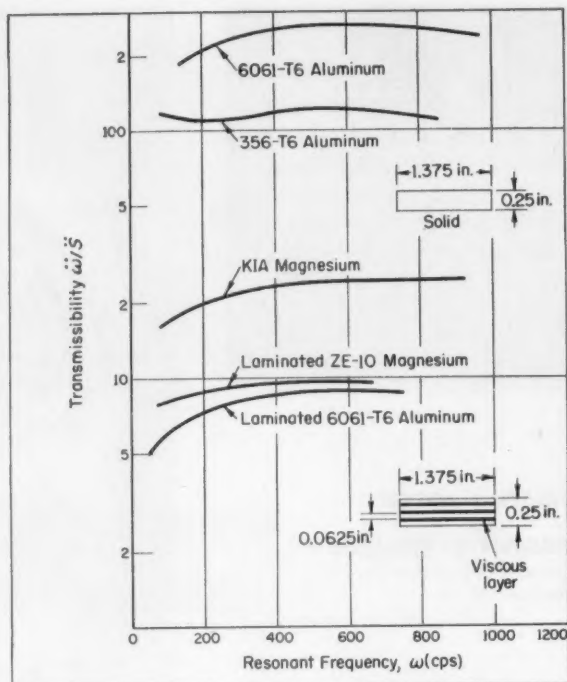
### Conclusions and Cautions

Reducing transmissibility by designing with highly damped structural materials reduces amplitudes as well as stresses at resonance. This prolongs structure life by increasing the number of load cycles before failure. In some instances, higher damping may actually reduce stress levels below the endurance limit, resulting in indefinite structure life.

In laying out a laminated structure, the designer should note that stiffnesses are not equal to those of a solid structure. In fact, increasing the number of laminations in a structure (for a given size) reduces stiffness and flexural rigidity.

Caution is also required in selecting the type of adhesive used in bonding the laminates. Some adhesives in both high and low-temperature environments actually increase transmissibility to the point where it once again becomes destructive to the structure and its auxiliaries.

ACKNOWLEDGEMENT is given to Dr. V. Panariti, Sanders Associates, for suggesting the use of laminated sandwich structures.



**3** Simulated missile-bulkhead setup permitted comparison of damping properties of laminated and solid plates and mounts. All plates (13-in. diam) were tested with all combinations of mounting brackets (2 1/4 x 2 3/4 in.). Code for plates and mounts indicates number and thickness of laminations. Material was 6061-T6 aluminum. Plot shows that a significant reduction in transmissibility can be achieved by laminating either plates or mounts.

## Computer Is Super Searcher At U. S. Patent Office

WASHINGTON—The equivalent of a full day's work for a skilled patent researcher may be polished off in a half hour by a card-controlled electronic computer in a system being tested at the Patent Office.

Patent Commissioner Robert C. Watson said that the Patent Office has long realized the need for an automated searching system to help industry and the public keep up with the flood of patents (issued at a 1000 a week rate). The bottleneck in technological progress caused by time-consuming patent searches can act as a "real deterrent to invention and capital investment," says Mr. Watson.

Major advantages—besides speed and efficiency—of the electronic patent-searching system are:

- A permanent record of areas of invention or discovery already mechanized is kept on magnetic tape and is therefore readily available for subsequent searches.
- In a search for specific patents, the computer identifies areas that otherwise may have been overlooked. In searching for patented chemical compounds, for instance, it can be instructed to indicate compounds with similar characteristics, since the latter might be capable of performing the required job better or more economically.
- Magnetic tapes containing complete patent office files on certain subjects could be purchased for use on machines the searcher owns or rents; thus several searches of the same files could be made at once.

First test of the new system is being made on a huge mass of patent data covering the polymer chemical group—one of the broadest and toughest areas in patent research.

A government-industry research team, composed of personnel from the Office of Research and Development at the Patent Office and the Research Div., Textile Fibers Dept., of E. I. du Pont de Nemours & Co. Inc., adapted the agency's punched-card file, which previously could be processed only on special equipment, to commercially available data-processing equipment, a Bendix G-15 digital computer.

## Now Rotary Torque Actuation, fully cushioned!



**Explore the cost reduction  
you can get with safe, low-cost, Carter Rotary  
Torque Actuators—Now with built-in cushions  
for longer, more dependable performance.**

**No by-pass leakage**

**Built-in cushions**

**Rotation to 370° as  
standard**

**Positive locking, no  
back-off under tension  
or power failure**

**Complete range of  
sizes**

**Proven in thousands of applications during the past 4 years!**

The Carter Rotary Torque Actuator has opened unlimited new possibilities in design and cost reduction. Transfer mechanisms, indexing, positioning, cam actions, valve operation, and many other applications become more effective and economical.

Here is safe, powerful, Rotary Torque. Actuated by air, oil, water or gas. Patented seal assures leakproof performance. Internal helical design prevents back-off under reverse tension, shock, vibration or complete power failure.

Available in 4, 5, 6, 8, 10 and 12" diameters. Special sizes and rotation requirements are available. Ask your Carter representative or write for all the details!

**Complete power package  
units available**

### SEND FOR NEW BULLETIN

Bulletin R.A. 500 gives complete details and specifications on the Carter Rotary Torque Actuators. Every engineer and designer should have a copy. Send for yours today!



# CARTER

**CONTROLS, INCORPORATED**

2914 Bernice Road, Lansing, Ill.

Phones: Lansing—CRanite 4-3305—Chicago—BAYport 1-7180

## New On-Off Static Control Locks DC Motors On Speed

Pulsates Input Voltage  
About 1000 Times per Sec

PULSES of line voltage from a new solid-state control keep dc motors on speed. The device locks a motor to within 0.1 per cent of rated rpm by continuously checking its operating rpm, and alternately speeding it up and slowing it down.

Developed by Globe Industries Inc., Dayton, Ohio, the control is reportedly unaffected by ambient temperature changes, vibration, shock, and voltage or load fluctuations. Small in size, one version, developed for fractional hp motors, is housed in a 2-cu in. enclosure. Control packages for 25-hp motors are only slightly larger.

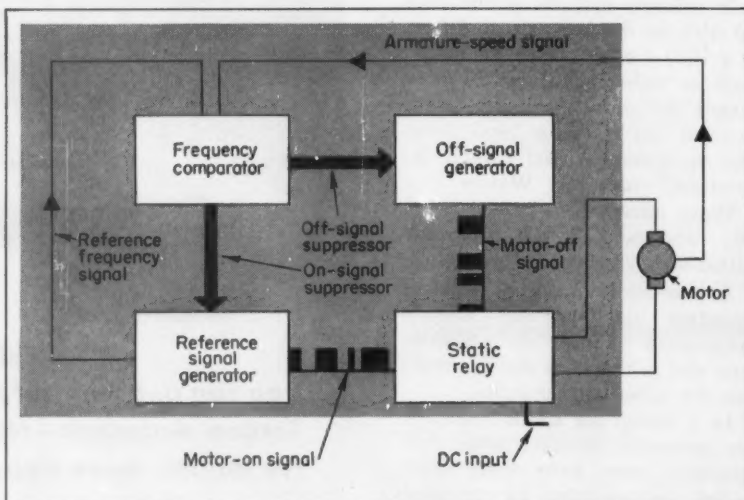
### Synchronized Slaves And Extra Torque:

Computer memory drums and tape-recorder drive motors can now be controlled to rotate at exactly the same speed, and any number of slave motors can be speed synchronized to a master motor or to a reference signal. Programming controls for missiles, satellites, and space vehicles are obvious applications, and use of the device with sequence timers, cameras, and similar equipment would improve their accuracies, say Globe engineers.

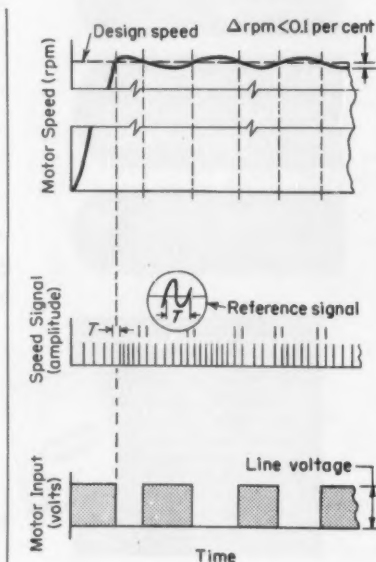
Power applied to the motor is always at full-rated value. Because dc motors develop about five times more starting torque than similarly rated ac synchronous motors, extra torque is therefore available for starting, running, and overload conditions. This gives the designer a choice of improved torque or reduced motor size for a specific job.

### Reference Signal Sets the Pace:

Motor speed, sensed at the armature by a coil or other electrical transducer, is transmitted as a pulsed signal—five breaks in the signal occur during each revolution of the motor. In the control, frequency of this speed signal is compared to that generated by a frequency oscillator. Oscillator frequency is preset so that when motor is at rated rpm the two frequencies



Control circuit consists of four parts: Frequency comparator, reference and off-signal generators, and static relay. The armature-speed signal is compared to the reference signal on a frequency basis. If the speed is too high, the frequency comparator suppresses the motor-on signal; if the speed is too low, it suppresses the motor-off signal. The combination of on and off signals results in about 1000 openings and closings of the static relay per second—about 1000 pulses of line voltage to the motor per second.



Motor speed is regulated by a bistable transistorized switching circuit. Although the speed fluctuates above and below rated rpm, control is maintained within 0.1 per cent of rated speed by the fast-acting solid-state relay.

Five speed pulses per revolution are sent back from the motor to the control circuit. There they are compared in frequency to that of a reference signal. When speed pulses spread out (motor too slow), the relay kicks in, then kicks out again when the motor is up to speed.

Full line voltage is supplied to the motor when speed is too low. It's interrupted when the motor reaches speed, re-established as soon as speed falls off. At no time are input pulses less than full-voltage pulses.

# WELDED STAINLESS TUBING SELLS THIS BOAT RAIL PACKAGE

DESIGN  
WITH WELDED  
TUBING

What's new in welded stainless tubing design? For one—this eye-catching package for pleasure boats.

Out of 1-inch stainless tubing and imagination, gleaming bow rails are now available in pre-cut, preformed package units ready for quick assembly on the decks they'll beautify.

Because welded stainless tubing is practical in price, uniform in dimension and furnished in a range of compositions and tempers, it is a designer's joy to work with. Remember this modern, strong, ever-bright and easy to clean material in your next project—and specify that it be supplied by a quality producer of welded steel tubing! • *Meanwhile, write for detailed Bulletin 8591.*

LC-604



**FORMED STEEL TUBE INSTITUTE, INC.**

1604 Hanna Building

Cleveland 15, Ohio

• Armco Steel Corp. • The Babcock & Wilcox Co., Tubular Products Div. • The Carpenter Steel Co., Alloy Tube Div. • Clayton Mark & Co. • Damascus Tube Co. • Jones & Laughlin Steel Corp., Electricweld Tube Div. • National Tube Div., United States Steel Corp. • Ohio Seamless Tube Div. of Copperweld Steel Co. • Republic Steel Corp., Steel and Tubes Div. • Revere Copper and Brass Inc., Rome Manufacturing Company Div. • Sawhill Tubular Products, Inc. • Southeastern Metals Co. • The Standard Tube Co. • Superior Tube Co. • Trent Tube Co., Subs. Crucible Steel Co. of America • Union Steel Corp. • Van Huffer Tube Corp. • Wall Tube & Metal Products Co.

are equal. When motor speed is low, the control switches (through a bi-stable transistorized relay) line voltage across the motor; when it's high, the control opens the motor circuit. Once the motor is at speed, on-off pulses, taking place at a rate of about 1000 per sec, lock it there.

Motor speed remains synchronized to the reference frequency signal even when environmental changes occur. Neither amplitude, wave form, nor duration of the speed signals introduce error. The only possible source for speed error is the reference oscillator.

Although reference oscillators now used by Globe give exceptionally accurate control, i.e., 0.1 per cent, even more accuracy will soon be possible. Globe has developed and is now testing a compact crystal oscillator designed to give accuracies measurable in parts per million.

## Electro-Magnetic "Fence" Curbs Curb-Jumping Automobiles

DETROIT—Keeping motorists a safe distance from the pavement's edge is the job of a low-cost electronic system called Electro Lane.

Developed by the Electronics-Instrumentation Dept. of General Motors Research Laboratories, the device works something like the "beam" which keeps airplane pilots on course between airports.

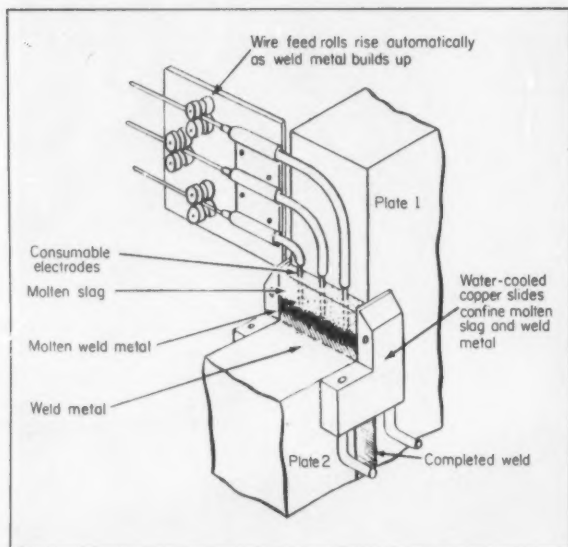
The Electro Lane system employs low-frequency wires, placed parallel to the pavement, and pick-up coils attached to bumpers of cars. The wires, installed on both sides of a one-way highway, or at sides and center of a two-way, two-lane road, create an "electrical fence."

Ferrite core pickup coils, hanging from both sides of the front bumper of a car, will pick up electrical

signals if the car comes within two or three feet of the wires. Signals, boosted by a transistorized amplifier, activate a buzzer on the car's instrument panel. The buzzer could even emit two distinct tones, indicating too far left or too far right.

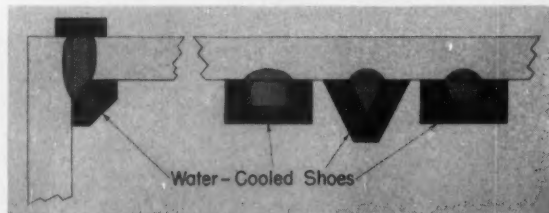
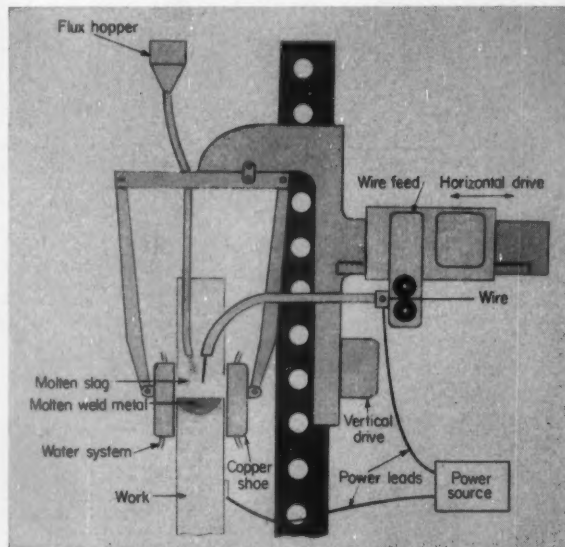
The system might first be used as a hang-on unit which a motorist could put on his car on entering a turnpike check-in station and take off when he left the turnpike, or it could be built into the vehicle.

Obvious safety advantages offered by Electro Lane include alerting a drowsy or inattentive driver; providing guidance through darkness, fog, or on snow-covered roads; and preventing collisions of cars traveling in opposite directions. A series of wires could also be installed across a road to produce a sequence of buzzes that would warn a driver when he is approaching an intersection stop sign or a toll station.



## One-Pass Welding for Heavy Plate

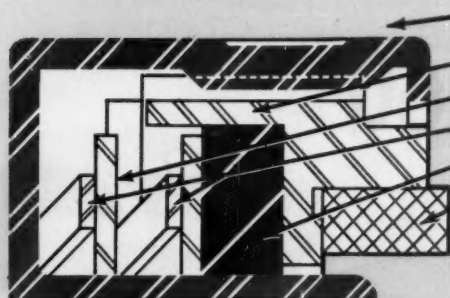
High heat created by electrical resistance of molten slag—which in turn melts both the filler metal and the adjacent parent metal—is the operating principle of a new automatic welding machine. It handles heavy steel sections (up to 10 in. thick), welding them continuously in one pass at speeds at least six times faster than conventional submerged-arc equipment. Called Electroslag welding, the new process can be used to make butt welds (above), "T" joints, corner welds with an inside fillet (right), and reinforcing surface welds (far right). Because it requires only a nominal 1-in. joint, it uses up to 50 per cent less filler metal than the submerged-arc process. Developed in Europe (Russia and Czechoslovakia), Electroslag equipment is being introduced in the U. S. by Arcos Corp., Philadelphia. Table lists mechanical properties of typical electroslag welds.



Mechanical Properties

	Yield Strength (1000 psi)	Tensile Strength (1000 psi)	Elongation in 2 in. (per cent)	Reduction in Area (per cent)
Mn-Mo	66.0	87.6	19	43
Mild Steel	48.7	74.1	28	59

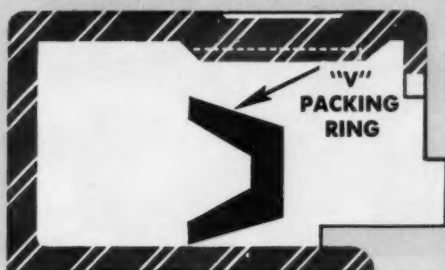
# GITS HH-TYPE SEAL SERIES



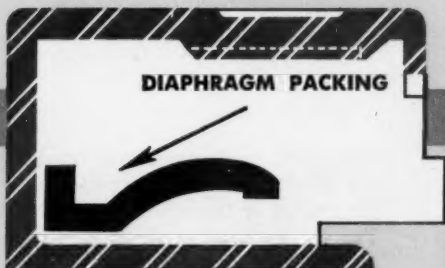
SHELL  
ADAPTER  
SEPARATOR  
SPRING  
FLAT PACKING RING  
SEAL RING



"O" RING PACKING



"V"  
PACKING  
RING



DIAPHRAGM PACKING



WEDGE PACKING RING

VITON "A"

All packings illustrated are available with new Viton "A" rubber compound, for highest temperature resistance and maximum resistance to aircraft and hydraulic fuels and lubricants.

Circle 416 on Page 19

# GITS

*Extra Flexibility For  
Your Seal Applications!*

## ONE SEAL ENVELOPE WITH CHOICE OF FIVE SEAL PACKINGS

Use of this one standard Gits HH-type seal envelope — with your choice of the five seal packing arrangements illustrated at left — permits effective sealing (in the same seal cavity) over the widest possible range of operating conditions. And all these Gits Shaft Seals meet standard minimum space requirements.

Standard metal parts are stainless steel, except when the Gits Engineering Department recommends other materials to suit specific applications.

The sealing and packing members are engineered of proper materials to suit the operating conditions of each individual application.

Gits maintains the most complete facilities for design, engineering, research, development and testing, as well as the most modern manufacturing equipment. The Gits Engineering Department, with almost half a century of experience, has the know-how to blend proper materials with outstanding design, to make seals work better for you. Send for full information.

## GITS BROS. MFG. CO.

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**NEW!** Gits engineering advancement practically eliminates hysteresis or drag. Write for full details.

# SAE Shifts into '60



## Cars by Computer?

When the annual model changeover was first conceived, it had a built-in safety factor in the form of a 2 to 3 year lead time. In recent years, this period of relaxed preparation has more often than not disappeared in the wake of mighty crash programs. The result has been the rise of the design-by-computer technique.

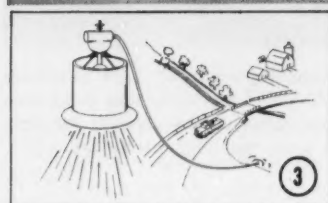
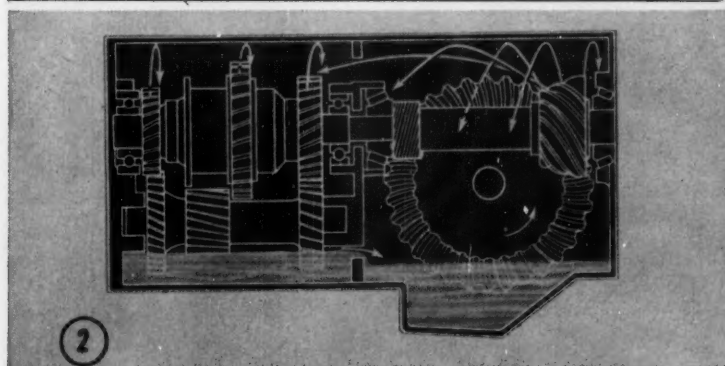
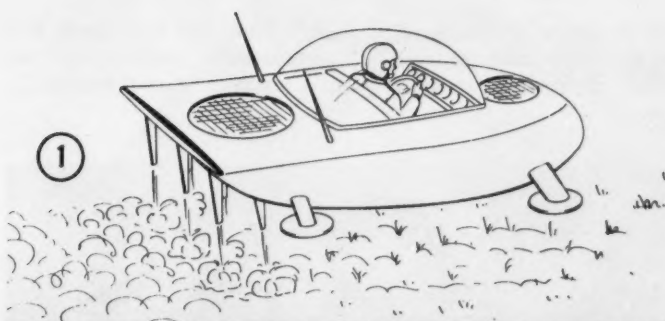
At the recent SAE meeting, engineers from Ford, Chrysler, and General Motors described suspension systems, drive trains, and other major subassemblies which were designed and even roadtested in the computing room. Since it is logical to assume that computers are at roughly the same stage as mass production was in Henry Ford's day, the future automobile designer may merely push buttons . . . using market research and sales figures as design criteria.

Chrysler's Harry E. Chesbrough touched on this situation in his acceptance of the SAE presidency for 1960. He cautioned Society members that "future scientific development in American engineering will be determined by whether the organization man can retain individuality in his thinking." He said: "We are entering a time when there will be a tendency to credit machines with progress . . . but engineers must never forget that organizations are made up of people, and it is people who build the machines."

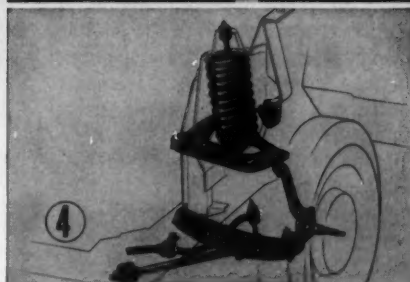
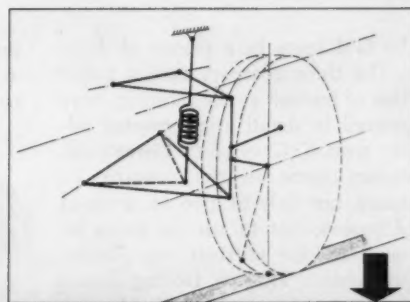
"DESIGN, production, and operation of all vehicles self-propelled on the ground or through the air" . . . This is the domain of big, cosmopolitan SAE. Almost half of the Society's 23,000-plus members converged on Detroit in January for their first annual meeting of the '60s.

The usual enthusiasm, characteristic of SAE annuals, this year more nearly resembled an unqualified optimism—a reflection, no doubt, of the public's wide acceptance of Detroit's major \$3000 product.

The perennial problem faced by most SAE members—getting a "new" car ready every year—breathes a great deal of life into the Society. Rapid change is a matter of routine in the industry, and



1. VTOL high-speed plow
2. Tryout for a transaxle lube
3. Ducted-fan crop sprinkler
4. Suspension by computer



this quality is evident in SAE.

When space travel moved from science-fiction to feasibility, the Society welcomed papers dealing with space-vehicle design. Now, at a typical annual meeting, sessions on new materials, techniques, and components for space share the program with traditional automotive sessions . . . a fact that not only accounts for fins on new models, but for significant engineering changes in both cars and missiles.

A typical example of SAE flexibility showed up on the exhibitors floor this year. An old and well-known manufacturer of car and truck engines displayed (on a pedestal) its latest product . . . a brand-new line of 6.5 hp go-cart engines.

The progressive outlook even prevailed at some of the technical ses-

sions: A paper outlining future trends in farm machinery described a "flying shower head" for watering crops by the acre. The king-size plumbing fixture consisted of a powerful pump on a tethered ducted-fan VTOL craft. It was designed to trail a water hose into the nearest lake.

There were also plenty of down-to-earth sessions at the meeting and one of the big topics concerned computers. Most engineers were unanimous in admiring the capabilities of their electronic associates, but at the same time they agreed on a common computer fault: The machines require too much pampering, in the form of programming, before they get around to accomplishing any work.

Researchers at GM are on the

trail of a solution, however, in the form of an almost elementary programming technique. Called DYANA (dynamics analyzer-programmer) the new method has been used to solve vibrational problems common to vehicle engineering. Using DYANA, the engineer describes, by means of a simple numerical code, what his vibration problem looks like in terms of masses, springs, dampers, etc. He also tells what answers he wants to see. The computer accepts the simple description of the problem and prepares the mathematical formulas. It then takes on the chore of writing detailed instructions for solving the formulas (i.e., the computer writes its own program). Problems that previously required several weeks of programming are being solved by

the GM team in a matter of days.

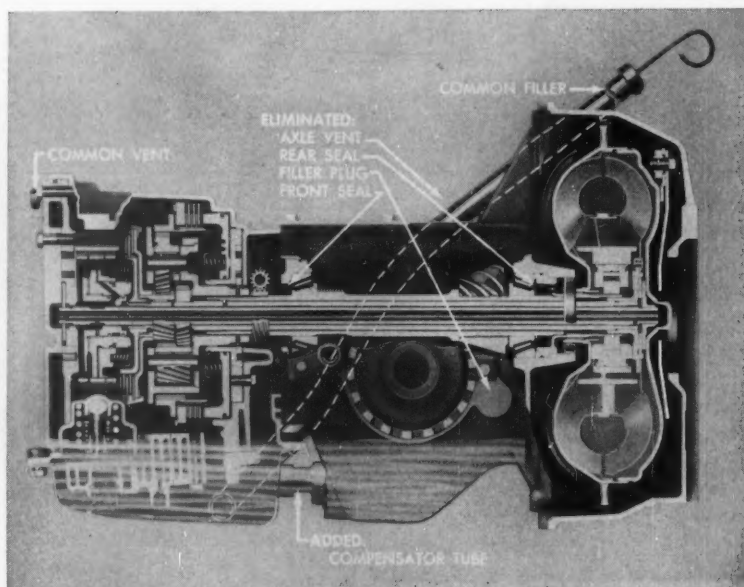
The three compact cars, a major item of interest at the meeting, were covered in detail at a crowded all-day session. Chevrolet's Corvair designers came to the meeting en masse, not only to give an armload of papers, but to stir up some interest in one of their top current problems. They're looking for a satisfactory transaxle fluid. Merging automatic transmission and rear axles into a single unit has apparently posed one of the toughest all-purpose lubrication problems on record. Chevy expected a solution to the problem early in Corvair's development, but could only admit to "some success" at this late date. The problem is particularly frustrating because the automobile industry has spent almost 35 years in developing hypoid-gear lubes and more than 20 years in developing automatic-transmission fluids. Simple blends of the two don't produce compatible operation of both transaxle units, and Chevy is testing everything that's available, including numerous additive-base stock combinations. "Results so far indicate that three mineral-oil base fluids and one synthetic-base fluid merit further investigation."

Nuclear energy, like the computer, is getting more and more popular as an automotive design tool. Engineers from Fairbanks, Morse described a brand-new technique—the use of radioactive cylinders—that promises to come up with data never before obtainable in engine design. It will be possible, for example, to chart the effects on cylinder wear of starting, idle, and cold-temperature operation; sudden load changes; speed; torque, and other important operating variables. Even more significant: Simultaneous data can be obtained on rings, cylinders, and other wearing parts of the engine through the use of different isotopes. And it will now be possible to monitor specific areas of the combustion chamber through selective irradiation of the cylinder.

How to eliminate "leakers" in seal application has been under study in GM research labs since 1957. A progress report given at the meeting included positive statements about some previously debatable questions. One rule: "A lip

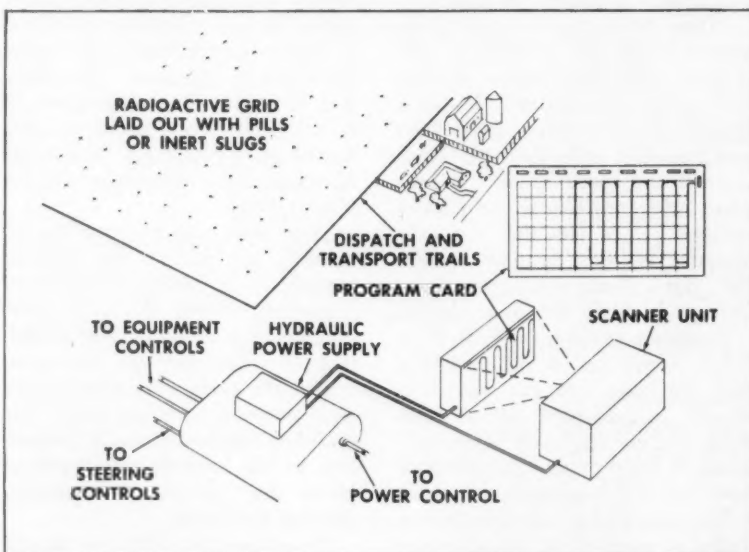
seal should no longer be considered as a piece of flexible material used to plug the hole around a rotating

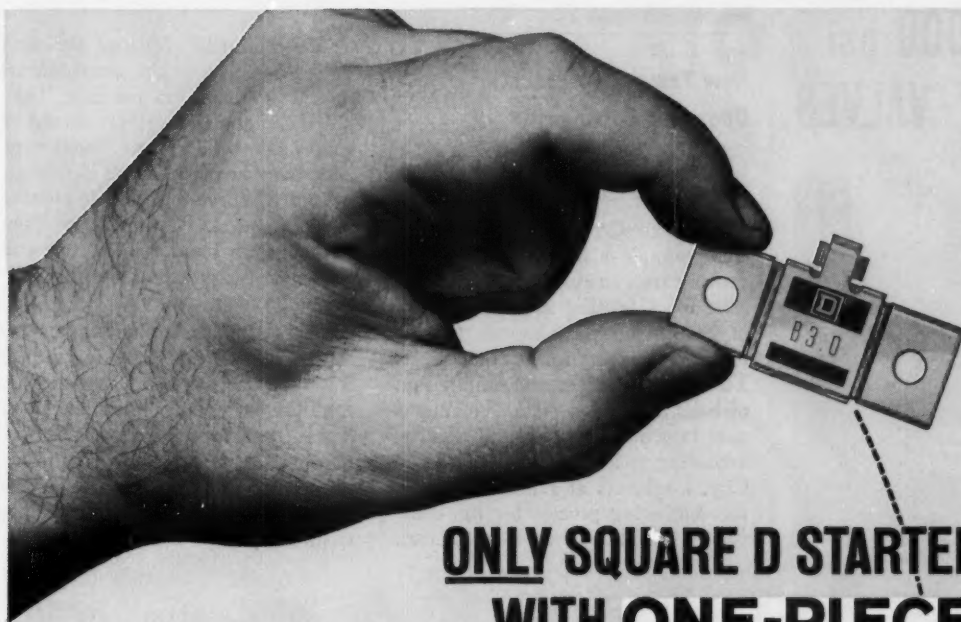
shaft." Shaft and seal should be a "precision-built assembly, not unlike a precision journal bearing."



Corvair needs a common fluid to use in transaxles equipped with automatic transmissions. Elimination of rotating shaft seals would cut costs; ease production and service problems. But no supplier has been able to come up with the right mixture, so Chevy engineers are attempting to brew the fluid themselves.

Real gentlemanly farming is not far off, according to predictions at the recent SAE meeting. This system is envisioned by H. C. Zeisloft, engineer at GM's AC Spark Plug Div.: Buried cables, radioactive pills, or inert metal would be laid out in the field in specific patterns. A scanning unit in the equipment would read the pattern and compare it with a programmed card. Comparison between the card and the scanner output would result in corrective signals to the vehicle. Since field layout would remain relatively stable, the equipment could repeat identical paths on different occasions (i.e., planting, then cultivating). A dispatch trail could even be set up to get the machinery from the barn to the field.





## ONLY SQUARE D STARTERS WITH ONE-PIECE OVERLOAD RELAYS GIVE *Absolute* PROTECTION!

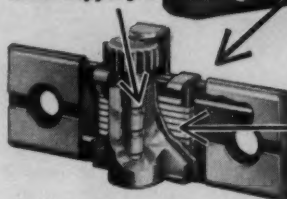
• Only Square D makes thermal overload relays with 1-piece construction—and only with 1-piece construction can you *know* you've installed the heater correctly. Square D 1-piece overload relays can be installed only one way. They are factory-assembled, individually tested and calibrated, completely tamper-proof. Repeated tripping will not affect accuracy.

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# SQUARE D COMPANY

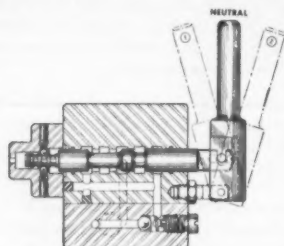
wherever electricity is distributed and controlled

## new 10,000 psi FOUR-WAY VALVES



**effortless operation  
for applications up to  
10,000 psi**

Have valving problems on hydraulic applications calling for high pressures up to 10,000 psi? This new GREENLEE Four-Way Valve may be your answer. Simple, trouble-free spool-type valve . . . completely balanced to provide effortless operation at any pressure in any position. It operates with the same ease at 10,000 psi as at 0 psi. Panel mounted for universal adaptability. Subplate available. Precision-made, precision-tested. (Max. leakage 4 cu. in. per minute at 10,000 psi.) Write today for illustrated data sheet.



GREENLEE Four-Way Valve is available in two models: No. 1717 (above) with detent-positioned control lever . . . No. 1704 with spring-centered control lever.

THE GREENLEE LINE ALSO INCLUDES A WIDE SELECTION OF HAND AND POWER-OPERATED HYDRAULIC PUMPS



**GREENLEE TOOL CO.**

1776 Columbia Ave., Rockford, Illinois

Circle 419 on Page 19

### ENGINEERING NEWS

#### **New Tempering Process Upgrades Castings**

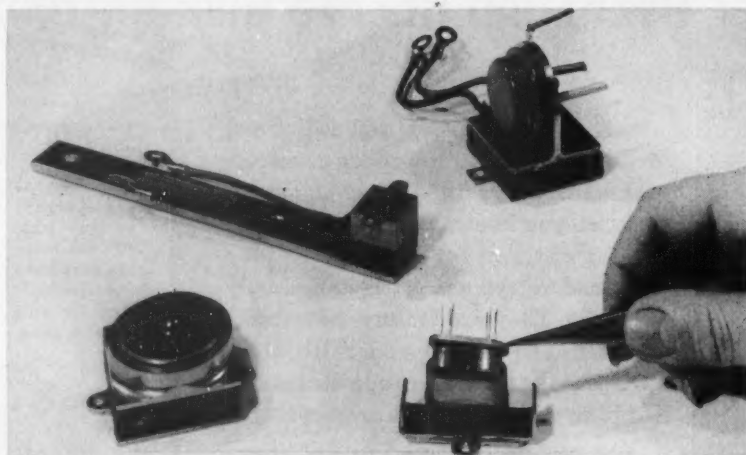
**First Application:  
"One-Piece" Earthmovers**

SALT LAKE CITY — "Determinant Tempering"—a new process for improving steel castings—makes it possible for a leading manufacturer of earthmoving equipment to cast major subassemblies in one piece. The result—besides the elimination of bolts and welds—is a tremendous gain in vehicle strength and rigidity, according to Eimco Corp., Salt Lake City. Engineers at Eimco developed the tempering process for the company's new line of crawler tractors.

"Determinant" castings are sand or mold-cooled in the conventional manner to just below red heat. They are then immediately transferred in the rough to a car or batch type heat-treat furnace already operating at the "S" curve to complete pearlite transformation. Castings are then air-cooled to room temperature and subsequently processed in the conventional manner.

These simple steps produce some remarkable effects: Cracking due to initial cooling stresses, flame cutting, grinding and other mechanical or flame processes is eliminated. Furthermore, castings show significant improvement in impact resistance, effective yield strength, fatigue life, weldability and hardenability.

#### **Thermoelectric Modules Cool Electronic Components**



**Flexibility in design** adapts thermoelectric-cooling modules to various sizes and types of transistors. Clockwise (starting from the tweezers), units are: 1. Mounting for chamber-cooling two transistors. 2. Basic module adapted for cooling four transistors. 3. Device with a chamber-type fitting for one transistor. 4. Basic 1.5-in. module adapted for a high-power transistor.

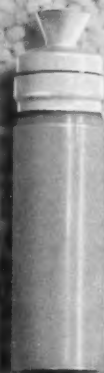
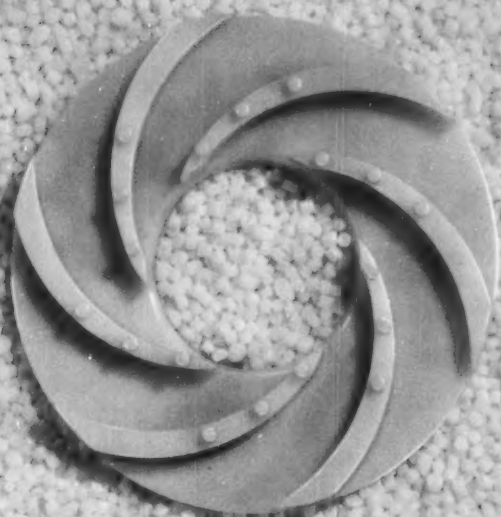
#### **Ambient Temperatures No Limit on Hot-Spot Relief**

PITTSBURGH — Thermoelectric coolers are now off-the-shelf items. A new line of electronic component cooling modules has been developed and is now being marketed by Westinghouse Electric Corp. Units operate silently, require little space, and cool at a controlled rate. They're designed in a variety of shapes and can be physically paralleled to cool a large area, or stacked in series to cool at an in-

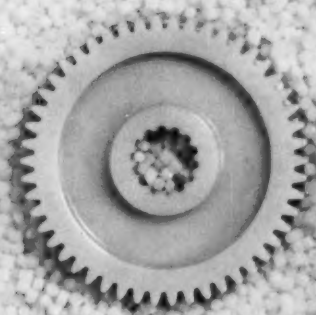
creased rate.

Ever since electronic components were first miniaturized to conserve weight and space, heat-dissipation problems have been troublesome. Heat distribution was nonuniform and hot spots effectively derated equipment and limited operating temperatures. But now, says D. W. Gunther, manager of Westinghouse's Semiconductor Dept., thermoelectric coolers can provide equipment with a lower temperature environment because they are

(Please turn to Page 41)



**Du Pont  
announces**



**Delrin<sup>®</sup>**  
ACETAL RESIN



**... a completely new engineering material offering  
a combination of properties unmatched by any other thermoplastic**

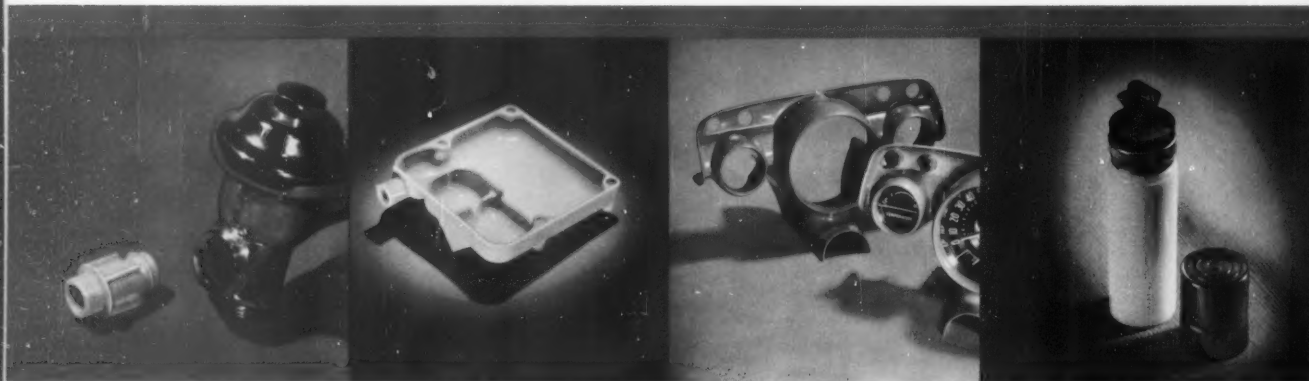
# This is Du Pont Delrin:<sup>®</sup>

"Delrin" acetal resin is a highly crystalline, stable form of polymerized formaldehyde. This completely new material offers you metal-like mechanical properties, such as a high degree of strength and rigidity, plus other properties that metals do not possess.

The combination of properties offered by "Delrin" is unequaled by any other thermoplastic. For example, "Delrin" has high dimensional stability, tensile and flexural strength, resilience and toughness. Most importantly, "Delrin" retains these desirable properties under a wide range of service conditions—temperature, humidity, solvents and stress.

Over the past three years, "Delrin" has been

## Typical performance and production advantages of "Delrin"



**A brass part** in a commercial flush valve was duplicated in "Delrin". This part operated perfectly for 18 months—the period of test—although it was completely and continuously immersed in water. The outstanding dimensional stability of "Delrin" under a wide variety of service conditions has also been proved, for example, in showerheads (continuously running water at 150°F.), and movie projector gears (run over 2,000 hours at ambient humidity).

**This textile solution pan** is ordinarily made of stainless steel. It must have resistance to oils and organic solvents, a clean, smooth surface; it also requires several threaded inserts plus other details. In normal quantities, stainless steel pans cost approximately \$25 each. Injection molded in "Delrin", the cost was quoted at about \$3 each. Testing showed that "Delrin" provided the required finish without machining, the needed solvent resistance, plus a weight saving of 75%.

**A zinc die-casting mold** was used to make this instrument cluster of "Delrin". Weight was reduced over the zinc component by almost 80%. In addition to manufacturing economies, further savings in assembly are indicated: self-tapping screws can be used, since the creep resistance of "Delrin" prevents loosening or stripping. These clusters can be molded in integral color or painted, and with a conventional mold would require little, if any, mechanical finishing.

**Aerosol containers** made of "Delrin" were shelf-stored for over a year; others stored for 3 months at 130°F. In both cases, the contents were still completely dischargeable. "Delrin" retains its strength and toughness for long periods, even when exposed to elevated temperatures and organic solvents. Equally important are the new opportunities for high styling opened by "Delrin"—the freedom to design in new shapes and integral colors to suit purchasing trends.

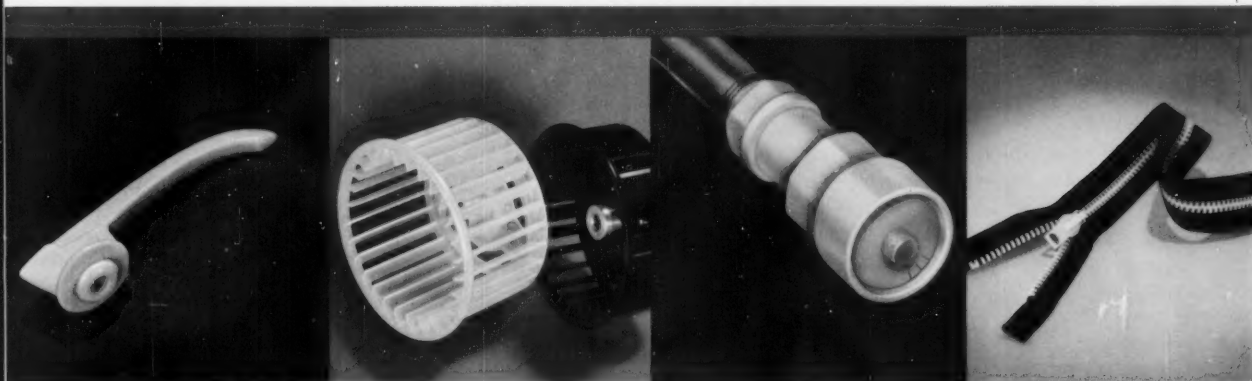
tested in hundreds of end-use applications by a host of industrial concerns. These tests have confirmed that parts made of "Delrin" can compete *on a performance and cost basis* with parts made of many metals, rubber, glass or wood. Of the various end-uses tested, 75% would normally be made of metal and another 10% of rubber, glass or wood. These tests have resulted in many applications of "Delrin" now being readied for commercial production—including gears, bearings, housings, containers, plumbing and hardware parts, pump impellers, "squirrel-cage" blowers, door handles, clothing fitments and many others.

In addition to metal-like performance, "Delrin" offers you the manufacturing economies inherent

in the production methods of the plastics industry. "Delrin" is easily injection molded, extruded, blow-molded or fabricated with conventional machine tools.

Illustrated below are a few of the applications of "Delrin" which have undergone extensive field service tests. The performance and economies listed were indicated during comparative evaluations made with materials in use at the time of the tests. These applications, together with additional data on the following page, may well suggest ways in which this versatile new engineering material can help *you* improve a product, lower its cost or develop new designs for your profit. Your inquiry is invited (see coupon on next page).

## evaluated during three years of field tests . . .



**Accessories** usually made of metal, such as automotive window cranks and refrigerator door handles, can be economically mass-produced in "Delrin" by injection molding. "Delrin" provides required strength and rigidity. Integral colors, a variety of surface effects and functional details can be produced in one operation. Less weight, improved styling, dependable performance and potential cost savings are made possible by "Delrin".

**Industrial components** such as this "squirrel-cage" blower—as well as a variety of gears, bearings and other mechanical parts—have demonstrated the ability of "Delrin" to compete with various metals on a performance and cost basis. "Delrin" offers excellent fatigue life even when immersed in oil or water. Rapid production of lightweight, intricate components by the injection molding process can lead to substantial manufacturing economies with "Delrin".

**Plumbing fixtures** made of "Delrin", such as this showerhead, offer the manufacturer new styling and design advantages...and the home owner new latitudes in bathroom décor. Injection molded in integral color, fixtures made of "Delrin" assure builders and home owners of long-term dimensional stability, freedom from rust and mineral build-up. Modern in design, they are durable and dependable in service, and provide opportunities for potential cost savings.

**Clothing fitments**, such as zippers, clasps and snaps, are also readily and economically molded in "Delrin". Stiffness, toughness and resistance to heat, body oils and perspiration make "Delrin" a logical choice for such uses. Your customers would welcome the light weight, colorability and warm-to-the-touch benefits "Delrin" offers. Extensive field tests have demonstrated that "Delrin" is one of the most promising new materials available to the fitments industry.

# TYPICAL PROPERTIES OF "DELTRIN" ACETAL RESIN

PROPERTY	ASTM NO.	TEMP.	500X		150X	
			500X	150X	500X	150X
Elongation		-68°F.	D638	13%	38%	
		73°F.	D638	15%	75%	
		158°F.	D638	330%	460%	
Impact strength, Izod		-40°F.	D256	1.2 ft.lb./in.	1.8 ft.lb./in.	
		73°F.	D256	1.4 ft.lb./in.	2.3 ft.lb./in.	
		-68°F.	D638	14,700 psi		
Tensile strength and yield point,		73°F.	D638	10,000 psi		
		158°F.	D638	7,500 psi		
Compressive stress at 1% deformation			D695	5,200 psi		
				18,000 psi		
		73°F.	D790	410,000 psi		
Flexural modulus,		170°F.	D790	190,000 psi		
		250°F.	D790	90,000 psi		
		100% RH 73°F.	D790	360,000 psi		
Flexural strength			D790	14,100 psi		
Shear strength			D732	9,510 psi		
Heat distortion temperature,		264 psi	D648	212°F.		
		66 psi	D648	338°F.		
Fatigue endurance limit, 50 to 100% RH 70°F.				5,000 psi		
				3,000 psi		
		100% RH 150°F.				
Water absorption, 24 hours immersion			D570	0.12%		
		equilibrium, 50% RH	D570	0.2%		
		equilibrium, immersion, 77°F.		0.9%		
Specific gravity			D792	1.425		
Rockwell hardness			D785	M94, R120		
Flammability			D635	1.1 in./min.		
Melting point (crystalline)				347°F.		
Flow temperature			D569	363°F.		

Deformation under load (2,000 psi at 122°F.)	D621	0.5%
Coefficient of linear thermal expansion	D696	$4.5 \times 10^{-5}$ per °F.
Taber abrasion (1000 gm. load, CS-17 wheel)	D1044	20 mg/1000 cycles
Thermal conductivity		1.6 BTU/hr./sq. ft./°F./in.
Specific heat		0.35 BTU/lb./°F.
Modulus of rigidity		178,000 psi
Poisson's ratio		0.35
Dielectric constant, 73°F., $10^2$ - $10^5$ cps	D150	3.7
Dissipation factor, 73°F., $10^2$ - $10^5$ cps	D150	.004
Dielectric strength, short time	D149	500 V/mil
Volume resistivity	D257	$6 \times 10^{14}$ ohm/cm
Resistivity	D257	$2 \times 10^{13}$ ohm
Arc resistance	D495	129 seconds (burns)

Permeability:	Water	1.9	(gms loss/24 hrs/100 in <sup>2</sup> area/mil thickness. Determined on bottles with 35-50 mil wall thickness.)
	Ethanol	0.2	
	Freon® 12-114 (20/80)	< 0.2	
	Methyl Salicylate	0.3	

Resistance to Organics:	Room Temp. 122° F.		% wgt. gain—12 mo. total immersion Vol. change proportional to wgt. change.
	CCl <sub>4</sub>	1.2 5.7	
	Toluene	2.6 2.8	
	Acetone	4.9 2.6	
	Alcohol	2.2 1.9	
	Ethyl Acetate	2.7 2.9	

\*These values are representative of those obtained under standard ASTM conditions and should not be used to design parts which function under different conditions. Since they are average values, they should not be used as minimums for material specifications.

## DELTRIN® offers design engineers a new combination of properties

"Delrin" acetal resin offers you a combination of properties and potential cost advantages never before offered by any single material. Specific values of typical properties of "Delrin" are listed in the table above . . . and the advantages implicit in these figures have been thoroughly tested in a wide variety of end-uses.

Today is your best opportunity to consider how Du Pont "Delrin" can help you improve the design of a product or develop your designs on new products. Within the next few weeks a new plant to manufacture "Delrin" in commercial

quantities will come on stream at Parkersburg, W. Va. This plant is your assurance that your design improvements can fast become practical realities. Commercial molders, already familiar with "Delrin", can provide you with valuable assistance in your problem.

A specialized group of Du Pont engineers, as well, can help you with their experience and knowledge gained during years of market development work with "Delrin". They may well have tested the very product or component you are considering.

FOR MORE SPECIFIC INFORMATION MAIL THIS COUPON

E. I. du Pont de Nemours & Co. (Inc.), Advertising Department  
Nemours Building, Rm. 99D, Wilmington 98, Delaware

I am interested in evaluating "Delrin" for the following use: \_\_\_\_\_

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COMPANY \_\_\_\_\_

POSITION \_\_\_\_\_

STREET \_\_\_\_\_

CITY \_\_\_\_\_

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In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

**DELTRIN®**  
ACETAL RESIN



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BETTER THINGS FOR BETTER LIVING  
...THROUGH CHEMISTRY

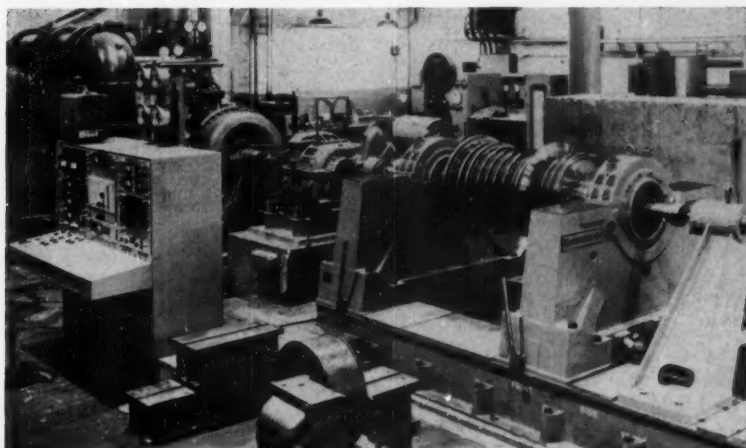
(Continued from Page 36)

not limited by ambient-air heat sinks. As a result, hot-spot failures can be significantly reduced.

The thermoelectric modules are rugged, operate with no moving parts, and can be mounted in any position. They can be constructed to form a package around the circuit, providing a compact space cooler for the electronic apparatus.

Heat-pumping capacity depends

on temperature difference between hot and cold surfaces of the cooler and on power input to the unit. A 25-C temperature differential can be maintained by a single module with a heat load of more than 17 Btu per hr, for example. To supplement the thermoelectric cooling, air or liquid cooling can be applied to the hot side of the module.



### High-Speed Balancer

Seven-ton parts can now be balanced while rotating at 12,000 rpm. A new dynamic balancing machine senses bearing vibrations on the order of four millionths of an inch displacement, even under high-load, high-speed conditions. Installed by De Laval Steam Turbine Co., Trenton, N. J., the machine automatically indicates where weight should be added. Amount and angular location of unbalance are displayed graphically, as are numerical values of horizontal and vertical components in any two preselected planes. Designed by Carl Schenck, Darmstadt, Germany, the machine accommodates rotating parts that weigh between 200 and 14,000 lb, rotating them at speeds from 1000 to 12,000 rpm.

## Meetings and Shows

Feb. 17-18—

Malleable Founders Society. Fifth Technical and Operating Conference to be held at the Wade Park Manor, Cleveland. Additional information can be obtained from society headquarters, 781 Union Commerce Bldg., Cleveland 14, Ohio.

Feb. 18-20—

National Society of Professional Engineers. Winter Meeting to be held at the Broadview Hotel, Wichita, Kans. Additional information

can be obtained from NSPE headquarters, 2029 K St. N.W., Washington 6, D. C.

March 6-9—

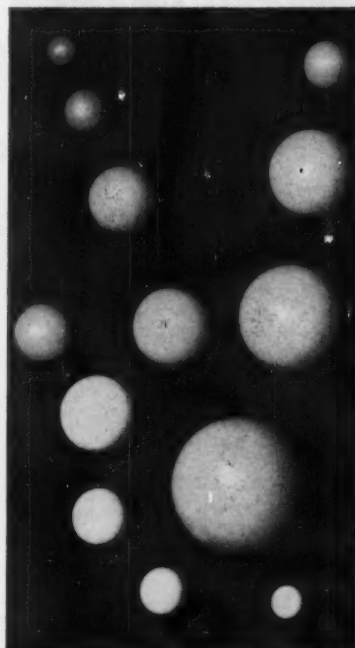
American Society of Mechanical Engineers. Gas Turbine Power and Hydraulic Conference to be held at the Rice Hotel, Houston. Additional information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

March 7—

Cleveland Engineering Society. Seventeenth Annual Machine Design Conference, sponsored by the Machine Design Div. of the society,

#### ENGINEERING NEWS

# CLEAN AND CLEAR BALLS



## OF NYLON AND TEFLON

Because of improved grinding and finishing methods, ITI Nylon and Teflon balls are FREE OF EMBEDDED SURFACE GRIT. Their clean, clear finish assures THE BEST in performance for your products.

These balls are available in all sizes — standard (carried in stock) and special. Samples free on letterhead request.

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**INDUSTRIAL TECTONICS, Inc.**  
MANUFACTURERS OF PRECISION BALLS AND BEARINGS  
3663 Jackson Road, Ann Arbor, Michigan

On this Simple  
Slotted Head Screw  
OUR CUSTOMER  
**SAVED**  
OVER \$20.00  
per thousand pieces



with Redesign  
for  
**COLD HEADING**  
by  
**CLARK**

**THE PROBLEM:**

Cost of this special slotted head screw, when machined from bar stock by our customer, was considered too high.

**SPECIAL REQUIREMENTS:**

Head must be tapered and slotted. Thread gage must go to within  $1\frac{1}{2}$  threads of shoulder.

**SOLUTION:**

Production by Clark utilizing cold heading process.

**SAVINGS TO CUSTOMER:**

Over \$20.00 per 1,000 pieces.  
Send sample or blueprint for prompt analysis and quotation ... at no obligation.

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**ENGINEERING NEWS**

to be held at the Cleveland Engineering and Scientific Center. Additional information can be obtained from Donald H. Cornish, Executive Director of CES, Cleveland Engineering and Scientific Center, 3100 Chester Ave., Cleveland 14, Ohio.

**March 7-8—**

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago. Further information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

**March 14-18—**

National Association of Corrosion Engineers. Annual Meeting to be held in Dallas. Additional information is available from NACE headquarters, 1061 M & M Bldg., Houston 2, Tex.

**March 15-17—**

Society of Automotive Engineers Inc. National Automobile Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

**March 21-24—**

Institute of Radio Engineers. National Convention and Radio Engineering Show to be held at the Waldorf Astoria Hotel and the Coliseum, New York. Further information is available from IRE headquarters, 1 E. 79th St., New York 21, N. Y.



"... and this is our gravity research department."

**March 22-24—**

Society of Automotive Engineers Inc. National Production Meeting to be held at the Statler Hilton Hotel, Cleveland. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

**March 29—**

Material Handling Institute Inc. Spring Meeting to be held at the Pittsburgh-Hilton Hotel, Pittsburgh. Additional information can be obtained from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

**March 29-31—**

22nd Annual American Power Conference, sponsored by Illinois Institute of Technology in co-operation with a total of 23 technical societies and educational institutions, to be held at the Hotel Sherman, Chicago. Further information is available from conference director R. A. Budenholzer, Mechanical Engineering Dept., Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

**April 4-7—**

American Management Association. 29th National Packaging Exposition to be held at Convention Hall, Atlantic City, N. J. The National Packaging Conference also will be held at Convention Hall, April 4-6. Further information is available from AMA headquarters, 1515 Broadway, New York 36, N. Y.

**April 4-8—**

Nuclear Congress to be held in the New York Coliseum, consists of the 6th Nuclear Engineering and Science Conference, the 8th NICB Atomic Energy in Industry Conference, and the 6th International Atomic Exposition. Congress is sponsored by 28 engineering, scientific, management, and technical organizations. Further information is available from 1960 Nuclear Congress, 33 W. 39th St., New York 18, N. Y.

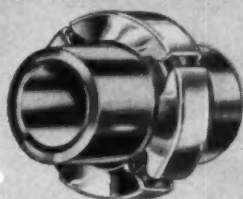
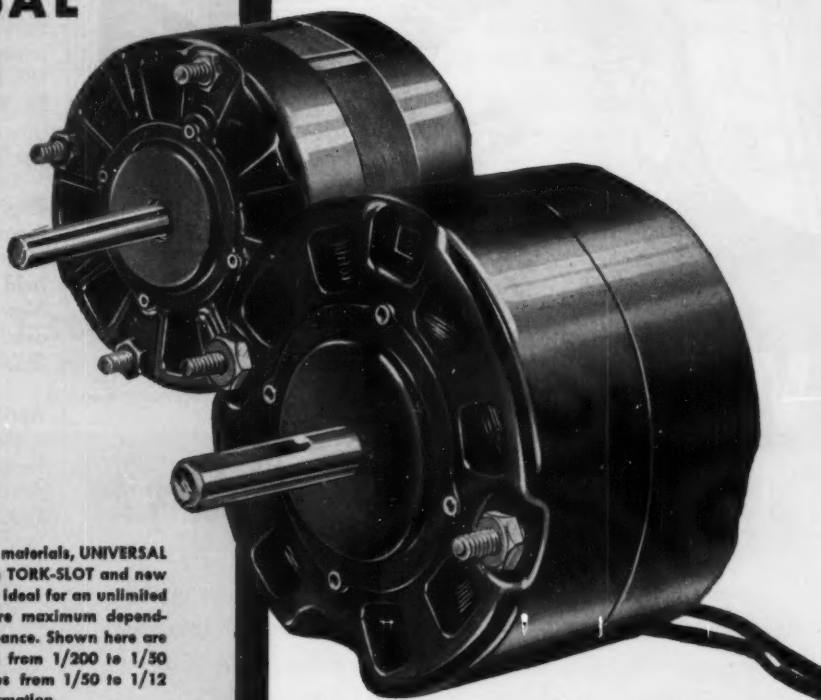
**April 5-8—**

Society of Automotive Engineers Inc. National Aeronautic Meeting (including production forum and engineering display) to be held at

# UNIVERSAL ELECTRIC FRACTIONAL HP MOTORS

with improved  
flux control  
and new  
free-aligning  
bearing

Rugged, precision built with quality materials, UNIVERSAL ELECTRIC Fractional HP Motors with TORK-SLOT and new free-aligning Universal Bearing are ideal for an unlimited number of applications that require maximum dependability with a minimum of maintenance. Shown here are the re-designed Type 118 in sizes from 1/200 to 1/50 HP and the new Type 23 in sizes from 1/50 to 1/12 HP. Write today for complete information.



## UNIVERSAL "FREE ALIGNING" BEARING

UNIVERSAL ELECTRIC motors also feature the new free-aligning Universal Bearing that eliminates fractional HP motor bearing problems due to misalignment. The new bearing, which has its axis of support in the center rather than at the end, is inherently in balance and can adjust to any shaft misalignment 100% of the time under any load conditions. The bearing provides an easier starting motor that runs without a whisper of sound.



## UNIVERSAL TORK-SLOT FLUX CONTROL

The operating efficiency and starting torque of UNIVERSAL ELECTRIC four-pole, shaded-pole fractional HP motors have been greatly improved by a patented reluctance slot. Called TORK-SLOT, this slot allows improved control over flux distribution and provides an isolated torque phase with a uniform air gap between yoke and rotor. Motors that incorporate the TORK-SLOT start easier and operate more efficiently over a wider range than motors with other types of reluctance slots.



**UNIVERSAL ELECTRIC COMPANY**  
PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 10



## is this design step really necessary?

Your problem power transmission component may already have been engineered by Charles Bond Company! Power transmission users the country over find it saves time and money to check with Bond first.

Time and again a review of the facts reveals that proven Bond *stock* components solve the problem without resorting to a new engineering approach, expensive dies and costly delay.

Bond's more than 60 years of manufacturing power transmission equipment has made it routine to specify our components for a great variety of design applications.

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### ENGINEERING NEWS

the Hotel Commodore, New York. Further information can be obtained from society headquarters, 485 Lexington Ave., New York 17, N. Y.

#### April 7-8—

American Society of Mechanical Engineers-Society for the Advancement of Management. Management Engineering Conference to be held at the Statler Hilton Hotel, New York. Further information is available from ASME, 29 W. 39th St., New York 18, N. Y.

#### April 11-13—

Fourth Conference on Manufacturing Automation to be held at Purdue University, Lafayette, Ind. Conference is sponsored by Purdue and *Automation* magazine. Further information can be obtained from K. E. Glancy, Div. of Adult Education, Purdue University.

#### April 18-19—

Third Annual Conference on Automatic Techniques to be held at the Sheraton-Cleveland Hotel, Cleveland. Additional information is available from conference publicity chairman, Room 530, 1213 W. Third St., Cleveland 13, Ohio.

#### April 19-21—

American Society of Lubrication Engineers. Annual Meeting and Exhibit to be held at the Netherland-Hilton Hotel, Cincinnati. Additional information is available from ASLE headquarters, 84 E. Randolph St., Chicago 1, Ill.

#### April 21-28—

American Society of Tool Engineers. Tool Show to be held in the Artillery Armory, Detroit. Further information can be obtained from ASTE headquarters, 10700 Puritan Ave., Detroit 38, Mich.

#### April 25-29—

American Welding Society. 41st Annual Convention and Welding Exposition to be held in Los Angeles. Technical sessions will be at the Biltmore Hotel; the show, at the Great Western Exhibit Center, April 26-28. Further information is available from AWS headquarters, 33 W. 39th St., New York 18, N. Y.

Quality control at Standard is second to none among the nation's major specialty product steel plants. It is maintained by the most accurate, up-to-date testing equipment available. The laboratory facilities operate around the clock to keep all vital information flowing to our metallurgists, shop foremen, mill and machine

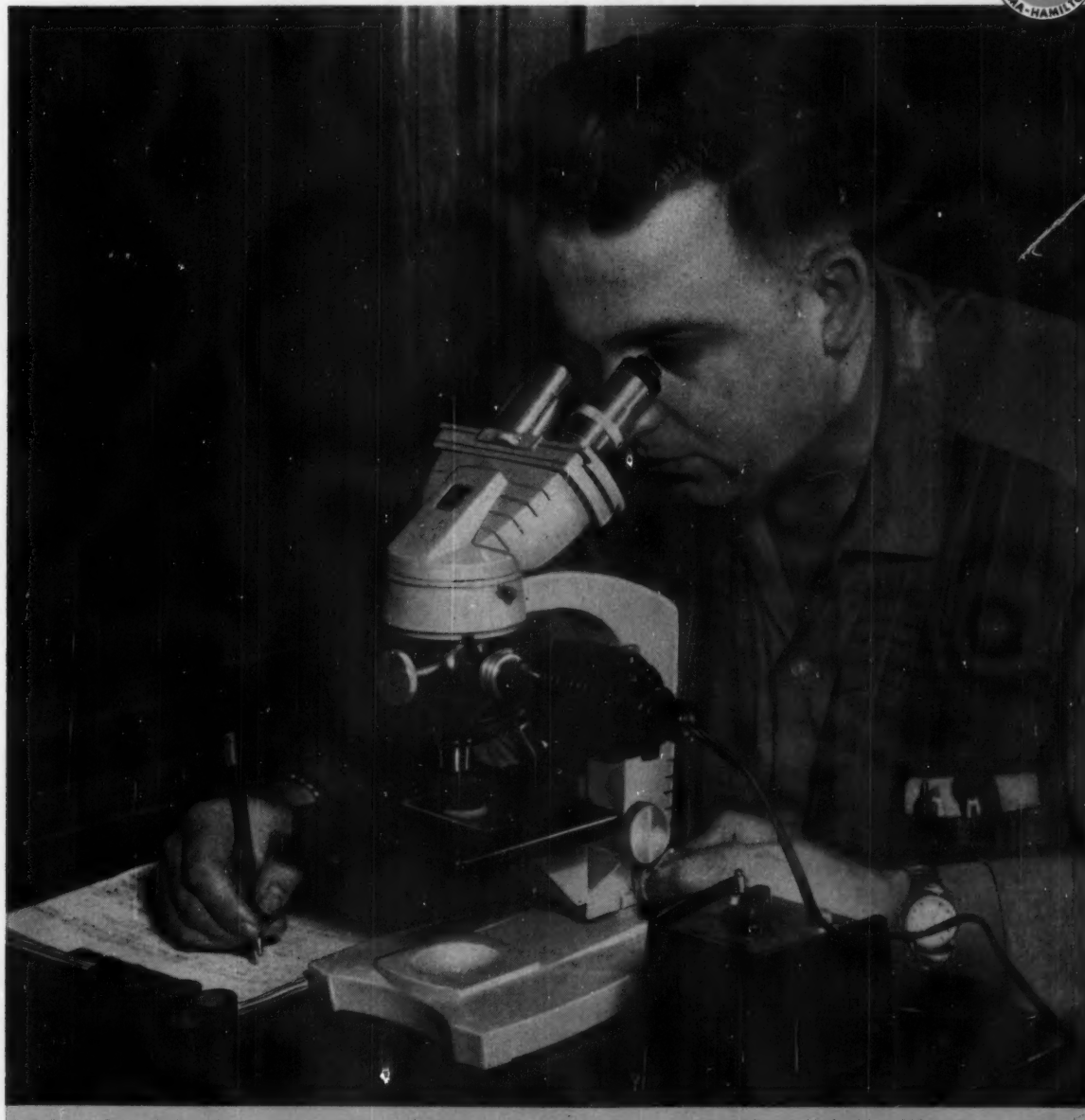
operators—as well as to plant management, and, of course, our customers.

Bring your next unusual product to us—we'll welcome the opportunity to serve you regardless of the alloy it might require. Send for the free illustrated booklet, "Quality Control at Standard."

## Standard Steel Works Division BALDWIN · LIMA · HAMILTON

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Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes



# MT. VERNON DIE CASTINGS help **STANLEY** develop stronger, lighter, tougher heavy- duty builders' saws

## CASE HISTORIES FROM MT. VERNON FILES

Stanley packs more power into its new line of low-cost, heavy-duty saws . . . and saves important weight doing it! They have been designed for greater utility, with such features as: Ball bearing guard — fingertip depth-or-bevel setting, uncluttered front — window brush-holder for simpler servicing, extra handling comfort, positive control, etc. Yet, with all these improvements, Stanley is still able to sell these better saws for less!

A big reason for this lower cost is Mt. Vernon's coordinated four-fold die casting service: designing, die-making, casting and machining. Mt. Vernon worked closely with Stanley\* to create light, thin-walled aluminum castings with strength to spare. All parts are produced with excellent surface finish to facilitate barrel burnishing. Many fit together without machining thereby contributing to lower manufacturing and assembly costs.

Stanley is typical of the leading manufacturers in the power tool industry who know and rely on Mt. Vernon's experience and facilities for die cast zinc and aluminum parts. As the largest independent die

casting company — with over 200,000 square feet under one roof — our services and equipment are ready to help solve your design and production problems. We'll be glad to discuss the advantages of die castings with you at any time. Just call your nearest Mt. Vernon sales representative.

\*Stanley Electric Tools, New Britain, Conn.



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# PROJECT 70,000,000

Since their introduction more than ten years ago, CLARE Type J Relays, with their small size, twin contact design and superior performance, have been first choice of design engineers for applications where component failure is intolerable.

Sensational demand for these relays has resulted in numerous imitations. Similar in appearance and published specifications, many have been represented as "just as good" as the original CLARE Type J Relays.

An independent laboratory has just completed exhaustive tests of CLARE Type J Relays and copies made by other well known manufacturers.

The results are here. Tests of the CLARE relays were discontinued at 70,000,000 cycles... *with no contact failure whatsoever.* All the other relay groups showed failure of 10% of their contacts before the end of 60,000,000 cycles (see graph). Some had 22% contact failure at 5,000,000 cycles.

*Let us tell you more about this important test. Call or write: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Limited, P. O. Box 134, Downsview, Ontario. Cable Address: CLARELAY.*

## CLARE RELAYS

FIRST in the industrial field



Independent  
tests\*  
prove There  
are no copies  
"just as good" as  
**CLARE J**  
type  
**RELAYS**

CLARE RELAYS  
(8 Form C)

70,000,000 Operations  
No Contact Failures

BRAND X1  
(8 Form C)

60,000,000 Operations  
11 Contact Failures

BRAND X2  
(8 Form C)

40,000,000 Operations  
12 Contact Failures

BRAND X3  
(8 Form C)

30,000,000 Operations  
8 Contact Failures

BRAND X4  
(8 Form C)

20,000,000 Operations  
12 Contact Failures

BRAND X5  
(8 Form C)

15,000,000 Operations  
7 Contact Failures

BRAND X6  
(8 Form C)

10,000,000 Operations  
11 Contact Failures

BRAND X7  
(8 Form C)

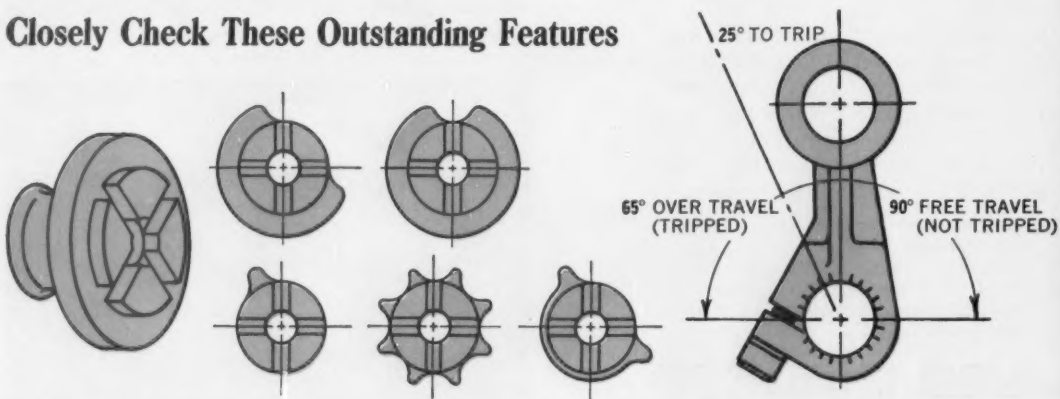
5,000,000 Operations  
18 Contact Failures

\*Failure of 10% of the total contacts involved eliminated any group from the test. Additional data available on request.

# The SL2 snap-lock • Newest NAMCO Machine Life Limit Switch

Snap-Lock Limit Switches, developed by National Acme to meet their own rigid specifications, have become industry's standard for reliable "machine life" service. Latest and most advanced in the complete line is the SL2. Built with typical machine tool precision and ruggedness, it will give millions of consistently fast, accurate contacts. Further, it is completely water and oiltight and has the heft to stand the bruising conditions imposed by heavy-duty machine applications. You owe it to yourself to closely examine the *combination* of performance characteristics that assure completely reliable limit switch performance under the most extreme operating conditions.

## Closely Check These Outstanding Features



**1. Infinite Operating Flexibility . . .** One simple interchangeable cam controls contact sequence . . . performance can be tailored to the specific needs of each application.

**2. Ample Overtravel and By-pass . . .** Sixty-five degree overtravel . . . 90° by-pass . . . 180° arc.

**3. Clockwise or counterclockwise motion . . .** Converting from clockwise to counterclockwise motion takes but a few seconds . . . no tools required.

**4. Light operating pressure . . .** Tripping action is 50%

less than previous models. Overtravel action requires only 8 pounds at 1½ inch radius.

**5. Shock-proof Mechanism . . .** Positive mechanical lock . . . prevents accidental movement due to shock or other external causes.

**6. Faster Contact Action . . .** Make and break speed up to 50% faster than predecessors . . . assures foolproof operating and wards off destructive arcing.

**7. Greater Contact Pressure . . .** Contact bounce minimized by use of new contact material that permits four times greater contact pressure.

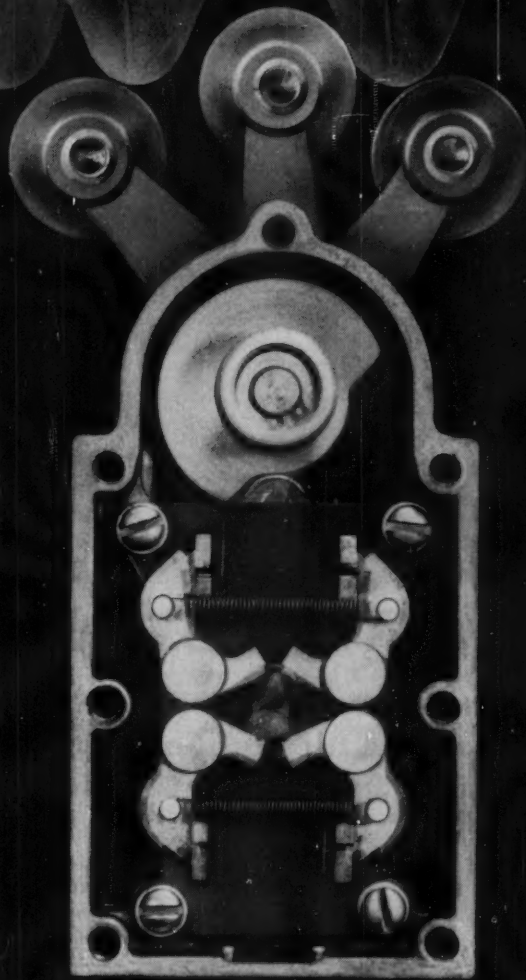
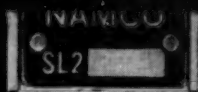
**Write for Bulletin EM-SL60 containing complete detailed information**

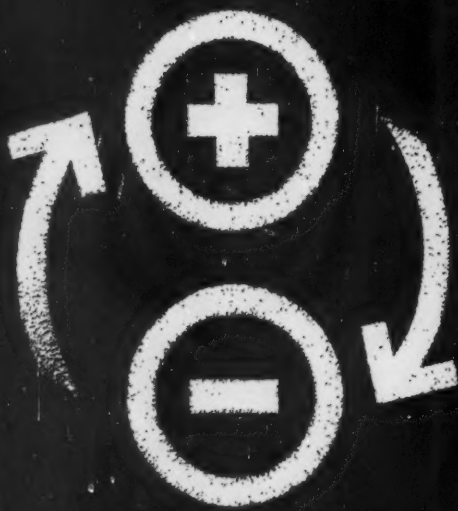
## National Acme

The National  
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188 E. 131st Street  
Cleveland 8, Ohio

Sales Offices: Newark 2, N.J.; Chicago 6, Ill.; Detroit 27, Mich.

Circle 427 on Page 19





## ASSIGNMENT: CORROSION

**How Lukens Application Research can help you  
find the right steel plate for the job**

Migrating ions—superimposed on a photomicrograph of corroded steel plate—symbolize one of metallurgy's oldest assignments: the battle against corrosion. Developing new tactics in this constant campaign is the job of our Application Engineering staff.

For example, called on early in the planning stages, Lukens engineers recently attacked almost identical problems for two large processing companies—and came up with two completely different solutions.

The first involved a sugar refiner's vacuum pans. Frequent and costly cleaning was required to head off corrosion and product contamination. Our staff's prior research and experience in the food equipment field led it to suggest *nickel-clad steel* for the

pans. (13% and 8% nickel-clad on A-285 backing steel.)

Cleaning and maintenance were equally costly to a leading chemical and dye company—in the protection of its nitrogen solution barge tanks. Here, our engineers found *stainless-clad steel* the most desirable answer. (12% 304L on A-212 backing steel.)

Armed with practical as well as technical knowledge of Lukens' wide range of special-duty steels, our Application Engineers have helped conquer corrosion on many fronts. That's why we say . . . *if your assignment is corrosion, let it be our assignment, too.* Contact Manager, Application Engineering, E-20, Services Building, Lukens Steel Company, Coatesville, Pa.

**Helping Industry  
Choose Steels  
That Fit The Job**



**ASK FOR THE BULLETIN ON LUKENS CLAD STEELS**



Report from James Roberts, Chief Engineer, Galion Iron Works & Manufacturing Co., Galion, Ohio.

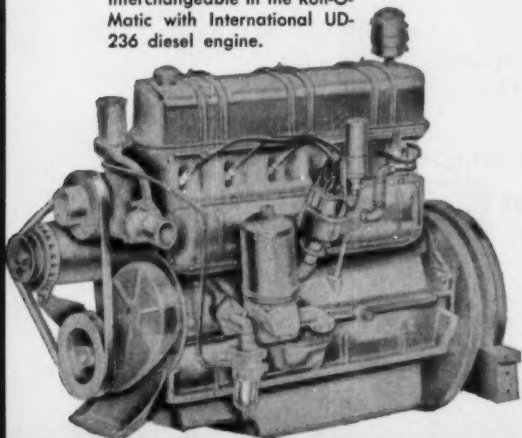
"We chose IH power for our pneumatic tire rollers because the wide speed range and favorable torque-speed curve of the International engines make it possible to have low-speed controlled operation for compacting, plus high-speed operation for traveling between jobs," says Mr. Roberts. "Other reasons we chose International were fast parts and service coverage, and operating economy."



## GALION'S power choice for new Roll-O-Matic based on 30-year experience with INTERNATIONAL

After specifying IH engines in their road-building equipment for over 30 years, Galion engineers are more convinced than ever of the sale-clinching, profit-building advantages of International power. This long and satisfactory experience shows that 1) International's wide range of power sizes, with features for extreme adaptability in every size, pre-

International UB-220 carbureted engine shown here is interchangeable in the Roll-O-Matic with International UD-236 diesel engine.



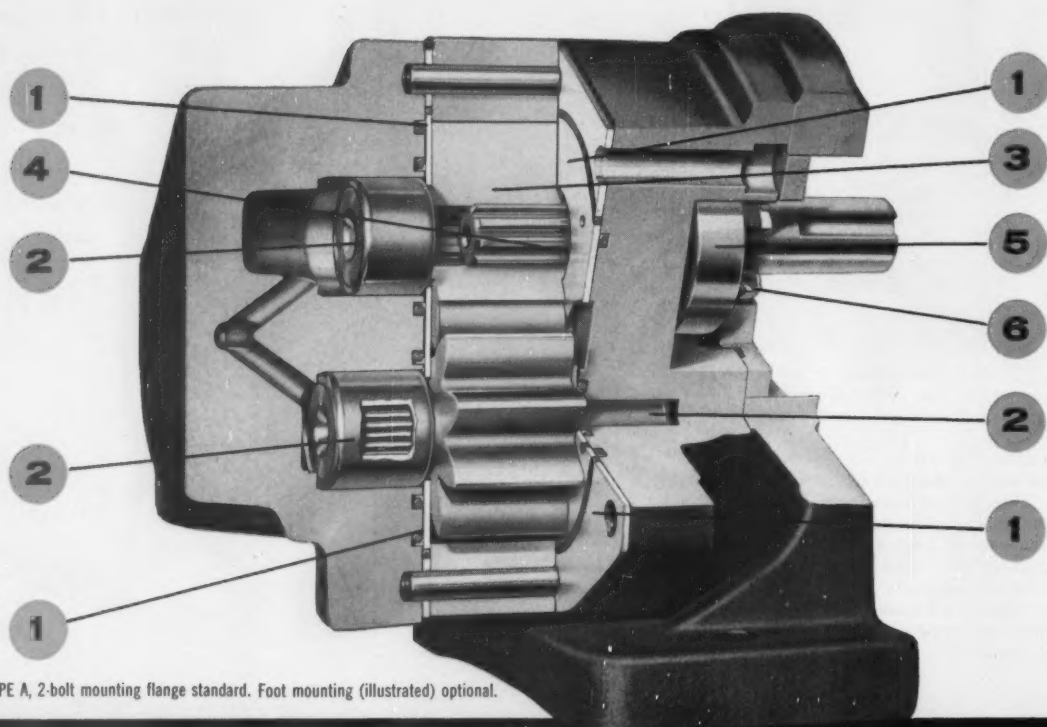
sents a choice that will exactly match design specifications and power requirements. 2) International's world-wide network of parts and service facilities assures prompt attention to on-the-job problems—any time, any place. 3) Galion customers are assured of long-lasting, low-cost power in their road-building equipment. That's why Galion engineers specify IH engines for products like their new 9-wheel, 12-ton, self-propelled, Roll-O-Matic shown above. This new roller, like other Galion products, offers a choice of IH gasoline or diesel power.

When selecting the engine to power your products, check into the complete International engine line—14 carbureted models, 10 diesels, from 16.8 to 385 max. hp. You'll like the one common feature of all 24 engines: fastest payback power for users. Just call or write International Harvester Co., Engine Sales Department, Construction Equipment Division, Melrose Park, Ill.



International Harvester Co., 180 N. Michigan Avenue, Chicago 1, Illinois  
A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors... Self-Propelled Scrapers and Bottom-Dump Wagons... Crawler and Rubber-Tired Loaders... Off-Highway Haulers... Diesel and Carbureted Engines... Motor Trucks... Farm Tractors and Equipment.

Circle 429 on Page 19



SAE TYPE A, 2-bolt mounting flange standard. Foot mounting (illustrated) optional.

## SAVES UP TO 4 HORSEPOWER! NEW WEBSTER "J" SERIES HYDRAULIC PUMP

HERE'S HOW WEBSTER PUTS NEW EFFICIENCY  
IN HYDRAULIC POWER . . .

1

PRESSURE BALANCED  
WEAR PLATES — for high  
volumetric efficiency;  
prevents clearance  
changes due to heat.

4

FREE-FLOATING  
INTERNAL  
SPLINE DRIVES —  
no key failures.

2

NEEDLE BEARINGS —  
power-saving,  
anti-friction  
operation.

5

THRUST BEARING ON  
DRIVE SHAFT — absorbs  
compound driving  
thrusts.

3

ONE PIECE GEAR AND  
BEARING JOURNAL UNITS  
— assure minimum  
deflection and proper  
alignment on both drive  
and idler assembly.

6

DOUBLE LIP SEAL ON  
DRIVE SHAFT — gives  
added protection against  
seal failure and dirt.

Now — hydraulic power for your biggest mobile rig  
and the toughest jobs you can put it on. Webster's  
new "J" pump delivers 2000 psi — does it on less  
fuel and saves up to 4 horsepower in the bargain!

It's the result of a combination of pressure  
balanced wear plates and anti-friction bearings.  
Here's top efficiency from all-new Webster design  
that rates 10% or more above others in competitive  
ratings. Moreover, you get equally important  
advanced features (see sectional view) to assure  
dependable, trouble-free service.

Webster "J" series pump is trim, *very compact* —  
fits into tight quarters, mounts easily. It's available  
in 10 sizes from 5 to 40 gpm. Ask your Webster  
Electric representative for all the facts on this  
powerful new pump — or write-direct  
for Bulletin HY1-1.

OIL HYDRAULICS DIVISION

WEBSTER



ELECTRIC

RACINE · WIS

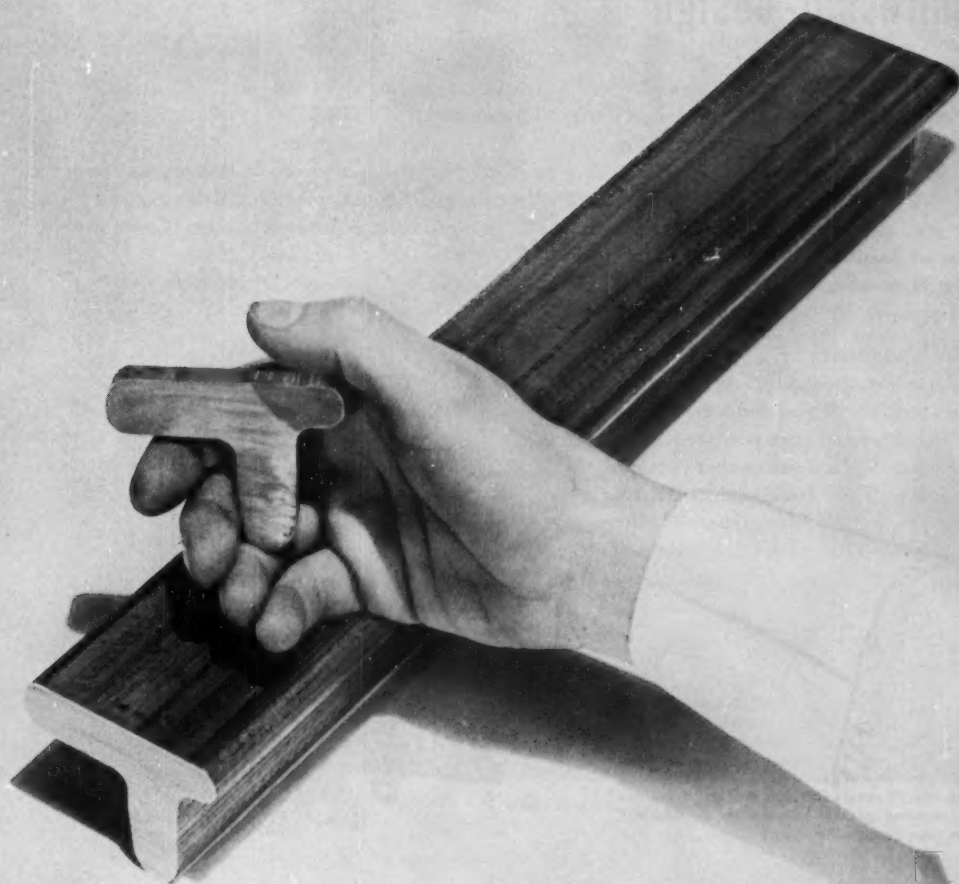
• Bulletin HY1-1

***Design for full production efficiency: Continuous-Cast Bronze Castings.***

Lower material costs, faster production, better products. Certainly a powerful set of reasons for evaluating Asarco's unique process of casting shapes in continuous lengths. The alloys produced by continuous casting are in accord with SAE, ASTM, and government specifications but their performance is demonstrably superior to similar alloys cast other ways. So superior in hardness, tensile, yield, and impact strength, that you may be able to substitute an Asarcon® bronze for a high-cost aluminum or manganese bronze. You get the shape you need in the exact lengths you need, with minimum clean-up necessary, machinable on high speed machines. Immediately available in 260 stock sizes: Asarcon 773 (SAE 660) Bearing Bronze, rods and tubes, 1/2" to 9" in diameter, lengths up to 105 inches. Special shapes can be made to order. Write today for free booklet on Asarco continuous-casting to Continuous-Cast Products Department, American Smelting and Refining Company, Barber, N. J. West Coast Distributor: Kingwell Bros., Ltd., 457 Minna St., San Francisco. In Canada: Federated Metals Canada, Ltd., Toronto and Montreal.

Circle 431 on Page 19

**CONTINUOUS-CAST DEPARTMENT OF**



**ASARCO**  
AMERICAN SMELTING AND REFINING COMPANY

# GRAMIX<sup>®</sup> COMPRESSOR BODY

## GENERAL ELECTRIC AIR CONDITIONER

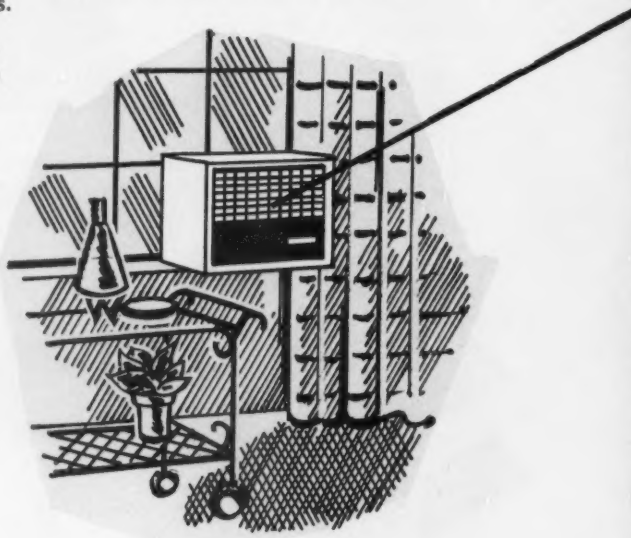
this GRAMIX part is a new concept in powder metallurgy techniques . . . engineered to meet requirements of GENERAL ELECTRIC'S new compressor design

This large, complex shaped compressor body which is employed in air conditioners manufactured by General Electric is an outstanding example of a GRAMIX part engineered and produced to exacting specifications. As in all GRAMIX products of powder metallurgy, the alloy was created to meet exacting physical properties required in this particular application. Correct briquetting, controlled sintering procedures, precise finishing operations and rigid quality control throughout the manufacturing process assures General Electric uniform, dependable GRAMIX parts. The production of this body as a product of powder metallurgy has also enabled General Electric to effect important design changes in their air conditioning units.

GRAMIX engineers have the experience, the techniques and the equipment to produce top quality products of powder metallurgy. No matter what type of part you need, no matter what characteristics that part must possess, it will pay you to select GRAMIX . . . and get both "job-engineered" alloys and quality-controlled production to meet each specific operating requirement.



Write today for these helpful engineering manuals. No. 18 covers design and metallurgical requirements and alloy selection of GRAMIX bearings. No. 19 covers GRAMIX Machine Parts and No. 21 contains general information on GRAMIX products from Powder Metallurgy.



# THE UNITED STATES

GRAPHITAR<sup>®</sup> CARBON-GRAPHITE • GRAMIX<sup>®</sup> POWDER METALLURGY • MEXICAN<sup>®</sup> GRAPHITE PRODUCTS • USG<sup>®</sup> BRUSHES

# IS VITAL PART IN



This part is shown  $1\frac{1}{2}$  times size. Actual weight:  $2\frac{1}{4}$  lbs.

X-271-2

## GRAPHITE COMPANY

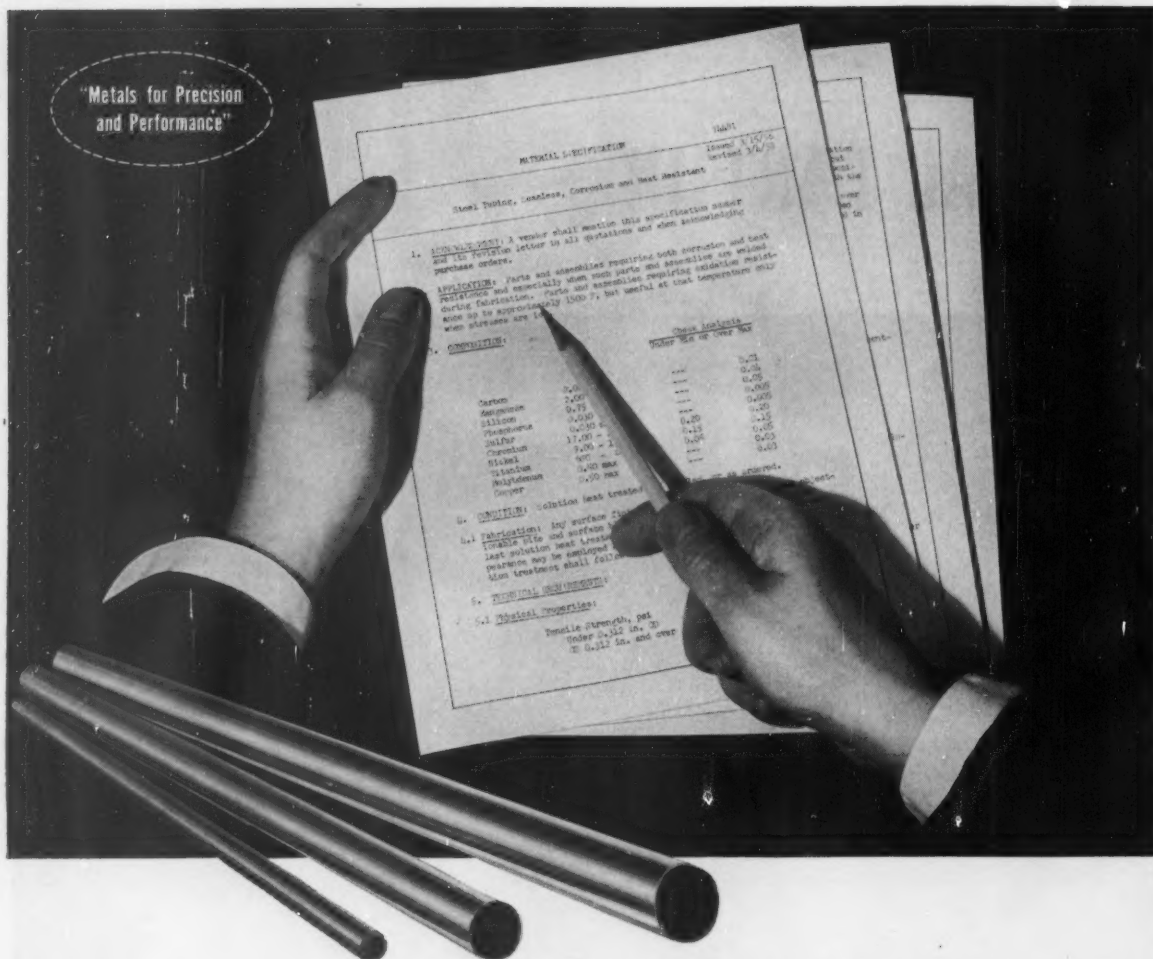
DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

February 4, 1960

Circle 432 on Page 19

55

"Metals for Precision  
and Performance"



*your  
individual  
tubing specs  
are a*  
**BISHOP  
specialty**

That special tubing you need doesn't have to be a frustrating problem — BISHOP delights in tackling tough specs. BISHOP is uniquely equipped to handle specials—long on experience and capacity, short on delivery. You'll get help within 24 hours from a Quick Service Team of sales, metallurgical and production experts—and unexcelled quality tubing . . . the finest made.

*Briefly, the Bishop Line . . .*

STAINLESS STEEL TUBING Seamless, Welded & Drawn	Mechanical, Aircraft, Capillary, Hypodermic also NEW Stabilized and L grades, precipitation hardening alloys	0.008" to 1.000" OD 0.003" to 0.083" wall
NICKEL & NICKEL ALLOY TUBING	All standard grades	up to 1.000" OD 0.065" wall max
TUBULAR FABRICATED PARTS	Flanged, flared, milled, slotted, swaged, threaded	
GLASS-TO-METAL SEALING ALLOYS	Low expansion alloys for glass sealing applications	
CLAD METALS & COMPOSITE WIRES	Base metals & precious metals in various combinations	
PLATINUM GROUP METALS	Fabricated products—chemicals	

CATALOGS, DATA SHEETS ON THE ABOVE SENT PROMPTLY ON REQUEST

Send in your individual specs for prompt handling, thorough analysis, prices, deliveries. Write, wire or phone Niagara 4-3100 or call your local steel service center.



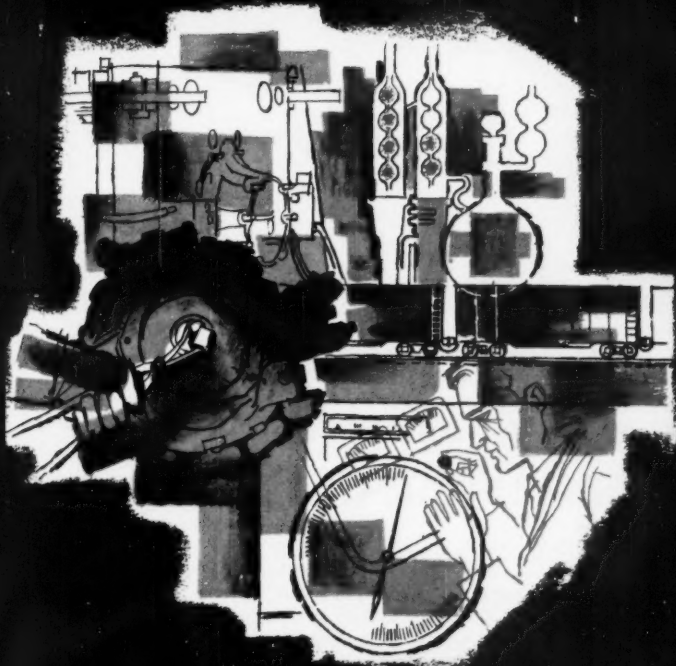
Tubular Products Division



**J. BISHOP & CO.**  
*platinum works*  
MALVERN, PENNSYLVANIA

# NOW from the FABRICAST plants of **CENTRAL FOUNDRY DIVISION**

**aluminum castings that improve  
products and meet cost requirements**



**Now CENTRAL FOUNDRY  
offers in aluminum . . .**

- **CAPACITY** to produce in quantity and ability to deliver on schedule
- **HIGH STANDARDS** of quality through rigid physical, chemical and metallurgical testing and control
- **CASTING METHODS** best suited to all types of design and production requirements
- **COMPLETE ENGINEERING SERVICES** to cut costs and improve casting design



# CAPACITY to produce in quantity and ability to deliver on schedule

The Fabricast plants of Central Foundry Division, located at Bedford, Indiana, and Jones Mills, Arkansas, have the facilities and the engineering services necessary to produce quality aluminum castings in production quantities and to deliver them on schedule. Complete pattern and die shop facilities are available to make wood and metal patterns as well as dies for permanent mold, die cast and investment parts.

This is advantageous to our customers because engineering changes can be incorporated in their equipment in a minimum of time; our trained personnel can give prompt delivery of intricate dies and experimental pattern equipment can be turned out readily. All grinding and cutting machinery for die work is available, including facilities to make cast-to-size parts; a completely equipped heat treating department utilizes salt bath furnaces.



Two modern, fully equipped plants located to serve you best.



Multiple-station permanent molding machines turn out large quantities of quality aluminum castings on schedule.



Central Foundry Division has a well equipped physical testing laboratory in which all of the standard physical tests on alloys can be performed. Special tests can also be conducted on castings to simulate service requirements if such testing is required.

## high standard of **QUALITY** through rigid physical, chemical and metallurgical testing and control

The Fabricast plants of Central Foundry Division maintain high standards of metallurgical quality for their cast products with well-equipped chemical, spectrographic, metallographic and physical testing laboratories. These

facilities include many of the industry's finest scientific instruments and testing devices; they are used to maintain rigid control over every stage of casting production from original alloying operations to finished casting.

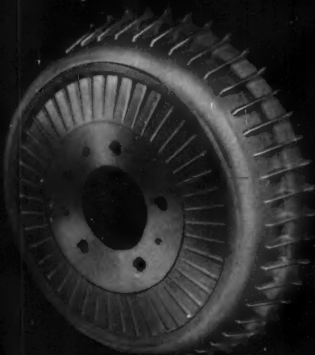
# casting METHODS best suited to all types of design and production requirements

It will help you, the designer of castings, to know that the Fabricast plants of Central Foundry Division produce aluminum castings by any one of four methods; die-casting, permanent mold, semi-permanent mold and sand casting. One of these methods will provide the best aluminum casting at the lowest possible cost. Before selecting the method by which an aluminum part is to be cast, consideration must be given to the design of the

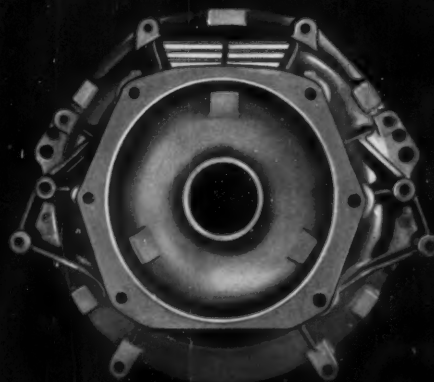
part, its size and its end use. Of equal importance is the number of parts to be produced and the alloy to be used. Central Foundry Division engineers, with years of specialized knowledge and training in casting aluminum, can be called upon for assistance in the design, alloy specification and in the choice of the casting method best suited to the production of your part.



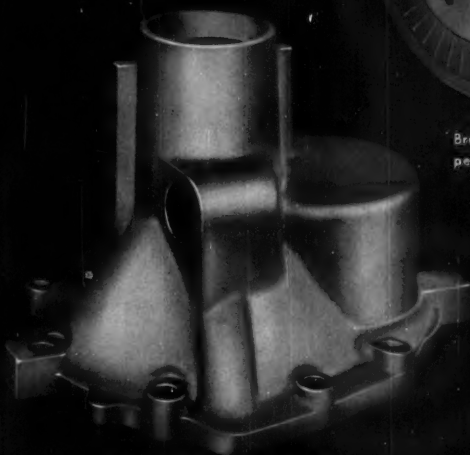
Automotive Piston cast by permanent mold process.



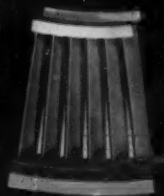
Brake Drum cast by permanent mold process.



Flywheel Housing made by the die casting process.



Rear Bearing Retainer made by the die casting process.



These Vane Segments are produced by investment casting, (an adaptation of the lost wax process). This method is used for the production of small precision parts from high temperature alloys and is the best possible method of casting intricate parts which must be cast-to-size.

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Postage  
Will be Paid  
by  
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First Class Permit No. 51 Sec. 34.9 P. L. & R. Saginaw, Michigan

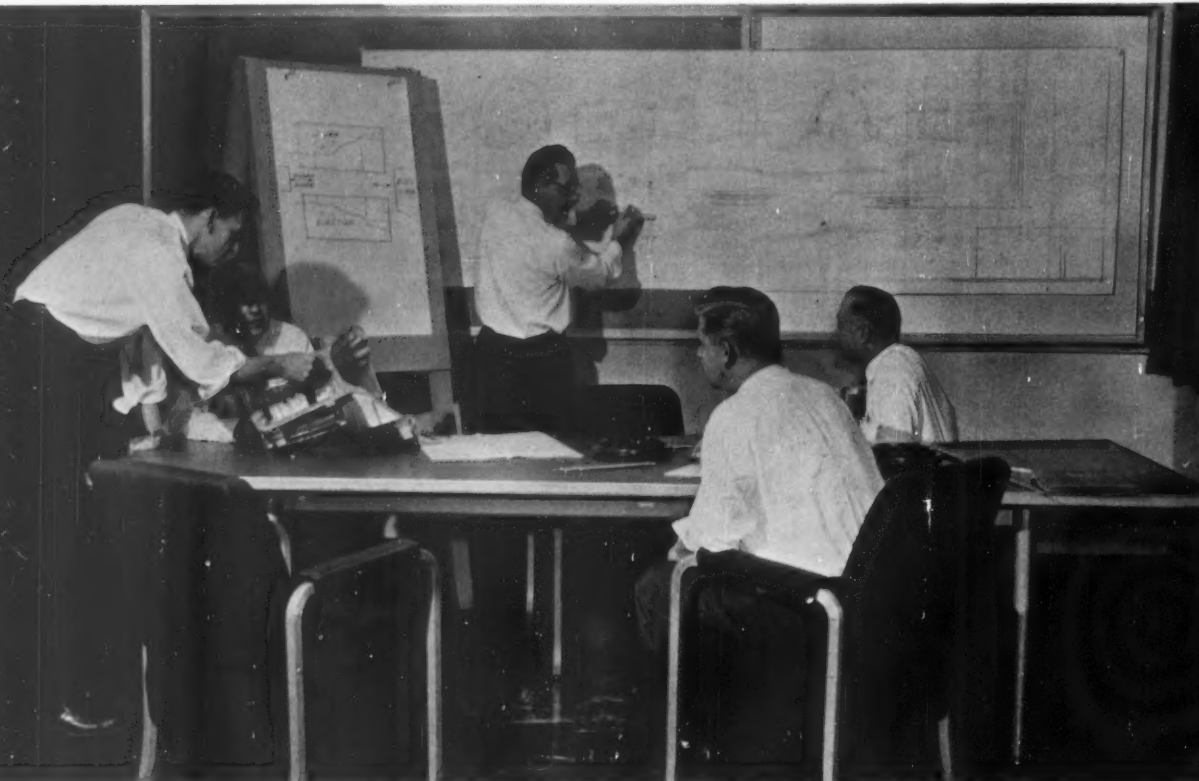
CENTRAL FOUNDRY DIVISION  
GENERAL MOTORS CORPORATION  
SAGINAW, MICHIGAN

Dept. A

# ENGINEERING SERVICES cut costs and improve casting design

A complete and competent staff of product development engineers, foundry engineers and modern engineering services are available to our customers to assist in casting design considerations. Frequently, foundry suggestions on casting design can reduce the cost of experimental and production parts and at the

same time improve the part functionally. Since casting design determines casting cost, close contact between foundry engineer and design engineer is necessary to create economical casting designs which are easily adapted to the high production methods utilized by Central Foundry.



## CENTRAL FOUNDRY DIVISION

GENERAL MOTORS CORPORATION, SAGINAW, MICHIGAN

Litho in U.S.A.

### CENTRAL FOUNDRY DIVISION

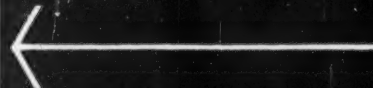
GENERAL MOTORS CORPORATION  
SAGINAW, MICHIGAN



- ☐ Send me a copy of your new 24 page book of Aluminum Castings
- ☐ Have Sales engineer call

NAME \_\_\_\_\_ TITLE \_\_\_\_\_  
COMPANY \_\_\_\_\_  
ADDRESS \_\_\_\_\_  
CITY \_\_\_\_\_ STATE \_\_\_\_\_

SIGN AND MAIL  
THIS BUSINESS  
REPLY CARD  
NOW!





# Flow Sheet<sup>1</sup>

HOKE REPORTS ON FLUID CONTROL

## A VALVE NAMED "DESIRE"

With apologies to Tennessee Williams, we really have produced a Solenoid Valve line based on your desires. We surveyed all the solenoid valve users we could find to determine what you wanted. The result is Hoke's "User Designed" Series 90 and 95, two-way and three-way, direct-acting solenoid valve line.

Thanks to you, we have much to brag about. Here's what we have been saying about these new valves: lightest weight — smallest size — no-hum operation — lowest temperature rise — lowest power consumption — stainless steel plunger — silver AC shading coils — easiest installation — packless construction — 360° rotatable housing — operates in any position.

We make them of forged brass or stainless steel, in 1/8" and 1/4" NPT size or JIC tube ends. There's a variety of AC and DC voltages. Class "A" coils are standard, but Class "H" are also available for temperatures above 212°F. For those with high insurance rates, we can supply explosion proof coil housings.

Now that we've bragged a bit, we must also apologize for our premature enthusiasm. We were so excited about this product that we stirred up a hornet's nest of interest before we were ready to deliver in quantity. Shipments were slow at the start, but now we can have any reasonable quantity of these "desirable" solenoid valves "on-stream" in your plant when you want them.

There's only one way to get conclusive performance proof — buy a valve. Ask for Bulletin SV-1159.



## What Goes With What?

This is a question engineers and chemists are constantly asking each other. Not that we want to do away with this healthy interplay at the water cooler, but we have put together a slide rule that answers all these questions. It lists 22 metals and materials and their degree of resistance to 247 corrosive agents.

Got yours? Write now while there are a few (thousand) left.

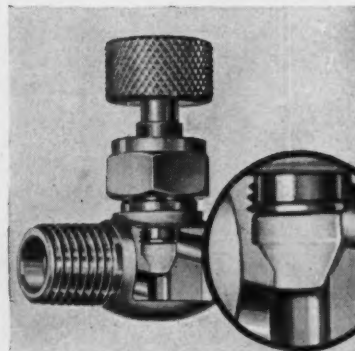


## HOKE'S NEW PLASTIC STEM TIPS END CHRONIC FAILURE PROBLEM

Galling and scoring valve seats plagued valve users and manufacturers for years, until somebody thought of using plastic stem points. This idea worked well at low pressures, but when the pressure increased — poof! — the valve blew its tip. Up to now, this problem had continued to bother valve makers.

Fortunately, a die-hard Hoke engineer insisted he could put a permanent plastic tip on a high pressure valve. We gave him his head and he gave us a plastic-tipped valve-stem (using either Kel-F or Nylon). His unique design incorporates a crimped metal shell that grabs the plastic tip and really holds!

Not satisfied with this monumental accomplishment, he proceeded to tackle leak problems at the stem packing. He put an O-ring seal on the stem and compressed it with a newly-designed Nylon collar. The collar serves a dual role, for it also prevents grit and other foreign matter from chewing up the O-ring. Valves of this new design have performed successfully up to 3500 psi. Our die-hard engineer not only



ended galling, but also seat leakage, stem leakage and wear problems — all at one swoop.

There's only one feature about this new development that worries us — since we do not expect replacements we may have designed ourselves right out of the valve business! We make these little dandies of either forged brass, bar stock or 316 Stainless, with 1/8" and 1/4" male connections. Temperature limit is 400°F. For the complete story, write, wire, phone or we'll come see you.

## Hoke "TECH-SPEC"



BALL TYPE



PISTON TYPE

## 570 SERIES CHECK VALVES

Designed for gas or liquid service at pressures to 5000 psi. Ball and piston types for extremely effective leak-tight closure, coupled with minimum flow resistance. Ball types in 1/8" and 1/4" sizes; piston types in 3/8" and 1/2" sizes. Temperature limits, -40 to 200°F. Body materials are Brass or 303SS. End construction is interchangeable with any combination of inlet and outlet connections. O-ring seals are available.

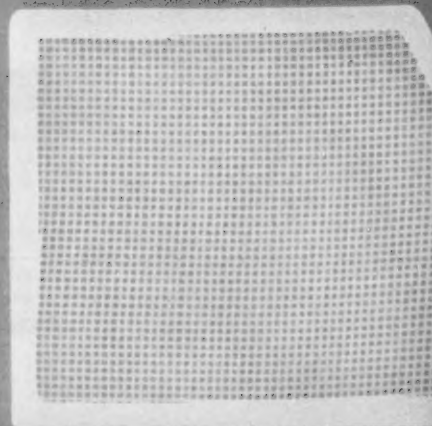
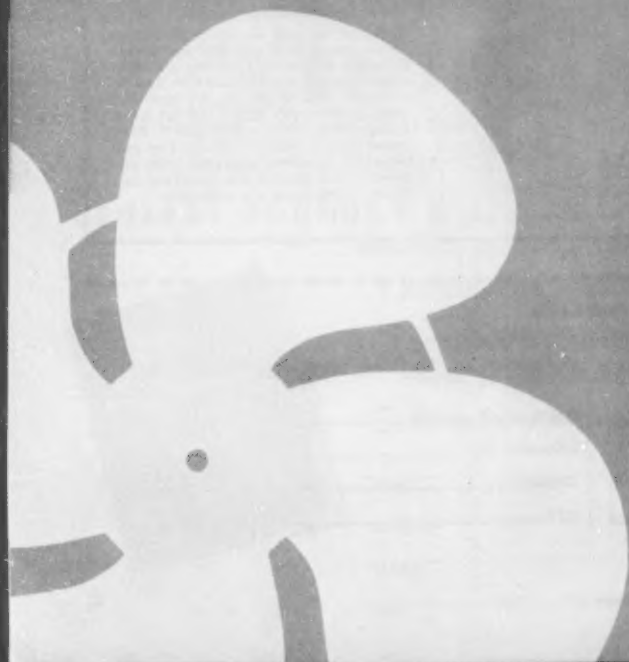
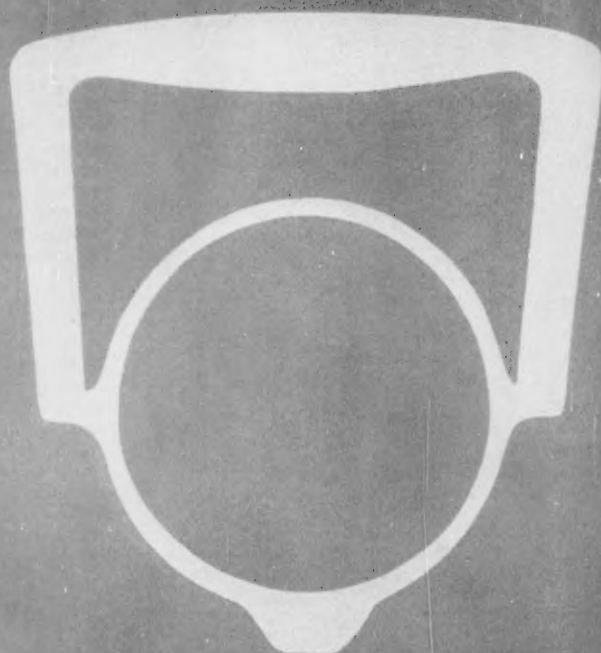
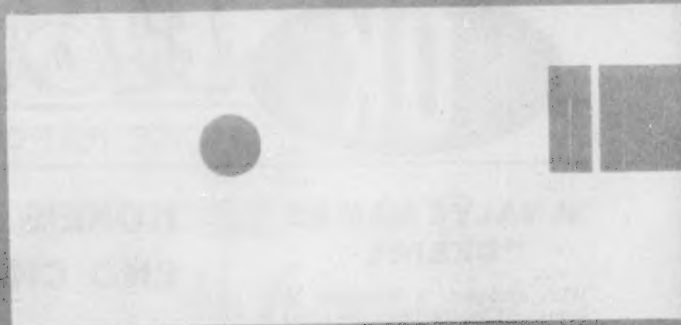
### HOKE, INCORPORATED

91 Piermont Road, Cresskill, N. J.

Send me complete information on the Hoke products checked below:

- ☐ Plastic Stem Tips
- ☐ Solenoid Valves
- ☐ 570 Series Check Valves
- ☐ FREE Corrosion Slide Rule
- ☐ Have a salesman call

NAME \_\_\_\_\_ TITLE \_\_\_\_\_  
 COMPANY \_\_\_\_\_  
 ADDRESS \_\_\_\_\_  
 CITY \_\_\_\_\_ STATE \_\_\_\_\_

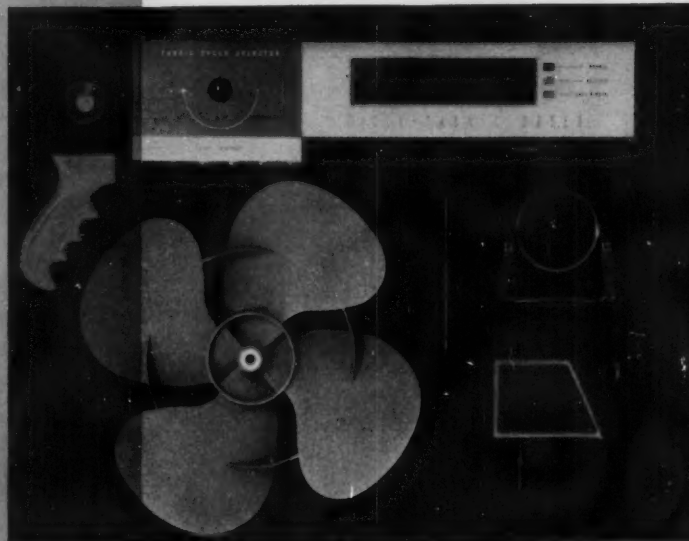


## How the custom molder can help bring your product idea to life

The custom molder is well-known as a mass producer of molded plastics parts and products. But he is much more. Most helpful to the designer, the custom molder knows the design limits of the different plastics. He can recommend the best formulation for the job. He can also engineer the design to capitalize on the inherent advantages of plastics materials and the efficiencies of plastics manufacturing. His toolmakers build the master molds to the closest tolerances. His productive facilities can turn out plastics parts with unusually consistent quality, at rates to meet the tightest schedules and budgets.

Monsanto keeps the custom molder supplied with molding formulations of Monsanto Polyethylene, Lustrex® Styrene, and Opalon® Vinyl, specially developed and constantly perfected to meet a wide range of design requirements.

Which molding compounds to consider? Use the Plastics Properties Calculator, an easy-to-read slide rule that provides comparative property data on the many different plastics molding materials. For your free calculator, write to Monsanto Chemical Company, Plastics Division, Room 732, Springfield 2, Mass.

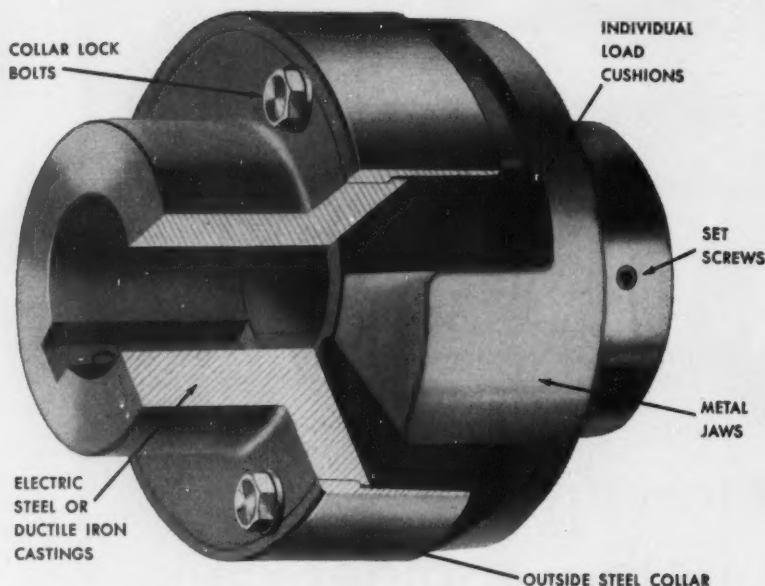


**MONSANTO ACTIVATOR IN PLASTICS**



**A Report To  
Equipment  
Manufacturers**

## **LOVEJOY TYPES C and H FLEXIBLE COUPLINGS UP TO 4250 hp.**



**Installed and  
Aligned  
In Minutes**

Just slide on the shaft, bring the jaws together and insert cushions. A twist of the bolts on the outside collar firmly retains the visible cushions.

Alignment is equally simple. Just use a straight edge. Gauges are not required.

**Eliminate  
Trouble and  
Service  
Calls**

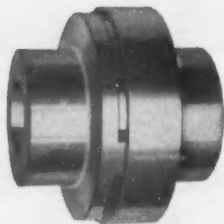
Lovejoy Flexible Couplings contain no intricate parts or mechanisms that require attention or can cause possible trouble. All parts, including cushions, are in plain sight for rapid inspection. Lubrication is never required. Water, oil, dirt or weather will not harm or in any way decrease efficiency.

The best care for Lovejoy Couplings is to *put 'em on shafts and let 'em alone.*

**Outlast  
Equipment  
Life**

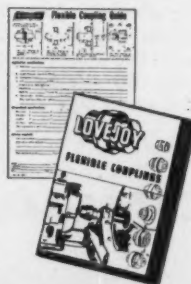
Bodies are carefully machined from electric steel or ductile iron castings. The load is entirely transmitted by cushion compression, eliminating metal-to-metal contact and resultant wear on metal parts and jaws.

Even the cushions last longer. First, they are furnished in the material best suited to the service. Second, on non-reversing loads, their life can be doubled simply by reversing or advancing.



Lovejoy Flexible Couplings can be delivered immediately from stock. Heavy-Duty Types C and H run from 18 to 4250 hp. at 1200 rpm. in a wide range of bore sizes. Other sizes and types run from .05 at 100 rpm. to 1020 hp. at 1600 rpm. to provide the most complete selection of couplings available to industry.

Request full information and ask for Catalog C-58. Give details or specifications for prompt quotation.



**Lovejoy**

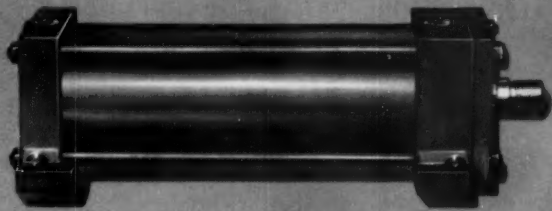
**FIRST NAME IN  
FLEXIBLE COUPLINGS**

**LOVEJOY FLEXIBLE COUPLING COMPANY**

**4818 W. LAKE STREET, CHICAGO 44, ILLINOIS**

Telephone EStebrook 9-3010 • Teletype TWX-CG-85

**SALES OFFICES THROUGHOUT THE CONTINENT**



Hannifin air power cylinders, available in a full range of mounting styles, bore sizes from 1 1/4" through 14", strokes to 20 feet. Cylinder bodies bored, then honed satin-smooth... for low friction, long packing life.



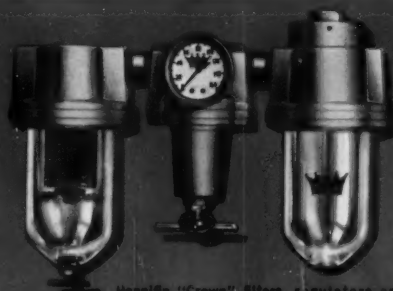
The Hannifin air motor combines a high-efficiency, leak-proof power cylinder and its electric control valve with built-in speed controls into one compact package. A single air line connection is needed, reducing installation costs.

## PARKER-HANNIFIN

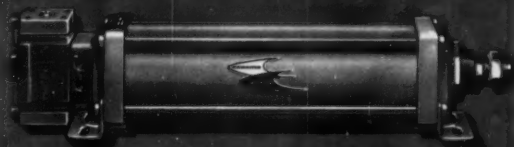
puts air to work  
without costly leaks

Now...complete pneumatic power systems, engineered for long leak-proof life, are available from your Parker-Hannifin man. Hannifin "Crown" units supply filtered, lubricated air at optimum pressure. Hannifin air valves shift quickly and seal bubble-tight. Hannifin air cylinders and air motors are low-friction, leak-proof. Parker "Push-lok" hose fittings and "Intru-lok" tube fittings provide quick, easy, leak-proof connections. The over-all result is more work from less air!

Our field engineering service helps you design your circuits and select the components. Many items are available locally, from Parker-Hannifin distributor stocks.



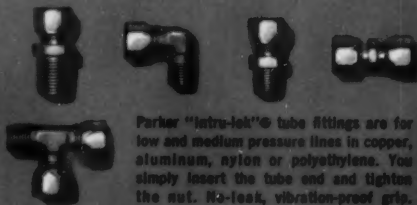
Hannifin "Crown" filters, regulators and lubricators—available singly or in any combination. Stocked in many cities by Parker-Hannifin distributors.



The Hannifin air motor combines a high-efficiency, leak-proof power cylinder and its electric control valve with built-in speed controls into one compact package. A single air line connection is needed, reducing installation costs.



A bench-backed hand push joins Parker "Push-lok" hose fittings to Parker hose. No tools required. Won't blow off.



Parker "Intru-lok"® tube fittings are for low and medium pressure lines in copper, aluminum, nylon or polyethylene. You simply insert the tube end and tighten the nut. No-leak, vibration-proof grip.

**Parker FITTINGS AND HOSE DIVISION**  
17325 Euclid Avenue, Cleveland 12, Ohio

**HANNIFIN COMPANY**  
555 S. Wolf Road, Des Plaines, Illinois



# FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY



## Technical-ities

By Fred E. Graves

### Why cap screws instead of studs?

Many types of products once fastened with studs are today assembled with cap screws. Why the change in preference?

Studs show certain advantages in large diameters and in high temperature applications. But when it comes to smaller sizes used in tapped holes, designers and production people have found more advantages in cap screws.

#### ASSEMBLY FACTORS

In fastener selection for a given application, you have to consider production and assembly as well as joint strength.

Obviously, studs require two wrenchings (first stud, then nut). Also, there's a more expensive close tolerance tapping job, since a stud takes an interference fit to stay tight and not withdraw when nut is backed off.

Cap screws require only a clearance fit. Used in a tapped casting, they can be repeatedly inserted and unscrewed without damage to threads.

#### HOW NOT TO USE STUDS

Studs are not meant to serve as dowels to locate and line up for fastening. To line up numerous studs and bring two pieces together raises assembly cost. Use dowel pins for alignment and use cap screws for fastening to achieve greater economy.

## Screw develops high thread tension . . . and stays locked in place



RB&W TENSILOCK screw, despite the friction of the toothed flange, develops 4000 pounds tension with on-torque of 240 inch-pounds.

Here is a locking fastener where the on-torque effort not only *anchors* the screw but also develops high preloading, or residual tension.

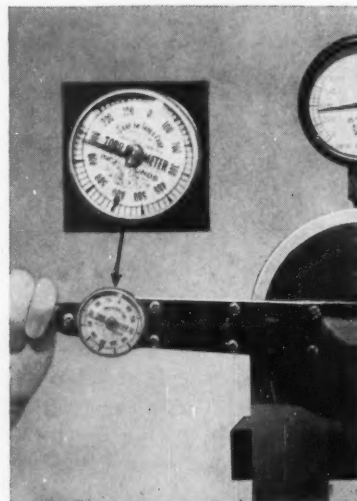
Like high tensile cap screws, RB&W's TENSILOCK\* screws also give a high thread tension to torque ratio. But there's one important difference. The TENSILOCK fasteners lock with *teeth* as well as high residual tension.

#### RATCHET-LIKE LOCKING

Carburized teeth on flange of this one-piece fastener are so angled as to afford easy torquing. They bite



into the seating surface when fastener is fully tightened. A circular groove in the flange increases flexing action and enables flange to



An off-torque of 330 inch-pounds fails to break loose the grip of the teeth. Tension is maintained by TENSILOCK screw.

maintain pressure on the imbedded teeth. To *loosen* a tightened TENSILOCK fastener thus takes much more effort than the on-torque. And it can be reused with little loss of this holding power.

#### FRICTION STOPS SLIPPAGE

The full clamping force exerted by these fasteners prevents slippage of the fastened members where lateral movement is possible because of large or eccentric holes. The positive gripping enables them to stay tight even under conditions of severe vibration or cyclic temperature fluctuations. RB&W TENSILOCK nuts also available. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

\*Trademark Pat. applied for

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

# FAR LESS STRESS IN LXS

## THE CHAIN WITH NO "STRESS RAISERS"!

Link-Belt LXS brings long-term economy and efficiency to the most punishing drive and conveying jobs. With its "FULL-ROUND" design, LXS has no stress concentration points . . . none of the sharp corners which frequently shorten the life of many ordinary chains.

LXS is available with straight or offset sidebars. For details, contact your nearest Link-Belt office. (See CHAINS in the yellow pages of your phone book.) Ask for our new, comprehensive Catalog 1050.

**LINK-BELT**

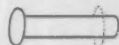
### CHAINS AND SPROCKETS

**LINK-BELT COMPANY:** Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

15,082



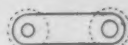
They're all of "FULL-ROUND" design



PINS



BUSHINGS



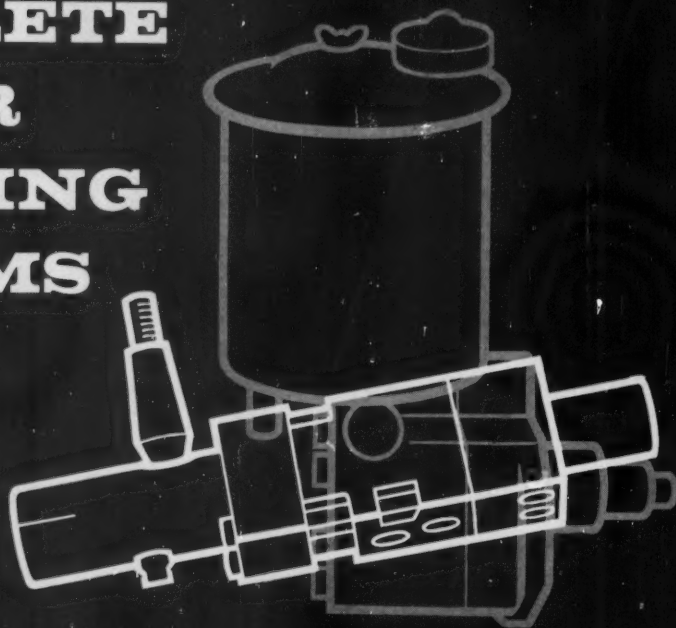
SIDEBARS

"FULL-ROUND" design eliminates traditional stress concentration points in Link-Belt LXS . . . provides maximum live bearing area between pins and bushings. Result: stress is distributed evenly.

Other LXS long-life features include controlled press fits plus use of selected steels and controlled hardening of all parts. All this contributes to greater uniformity, greater endurance.



# ONLY **VICKERS** OFFERS NEW AND COMPLETE POWER STEERING SYSTEMS



## Complete System Responsibility

### VANE PUMPS FOR BEST OPERATION

The Vickers power steering system utilizes vane pumps designed and built to last much longer than other type pumps. Further, they exert virtually no load on the starter like gear pumps do on those cold morning starts.

### WORLDWIDE STOCKS AND INTERCHANGEABILITY

If part of your production goes into export, or if you manufacture abroad, consider this: Vickers products are built in plants throughout the free world . . . and all parts from all plants are completely interchangeable. Wherever your equipment is working, there are Vickers parts nearby.

### FOR ALL THE DATA . . .



New bulletin gives complete information on this important breakthrough in power steering design and manufacture. It contains dimensions, ratings and other data so you can draw your own comparisons. Write for Bulletin M5110.

# For axle loadings from 1,500 lbs. to 128,000 lbs.

Manufacturers of mobile equipment can now install a completely tailor-made power steering system using standard, production built components. These components are designed to occupy less space because of compact design and high pressure operation (up to 2000 psi). Size for size you get double the thrust for equivalent price.

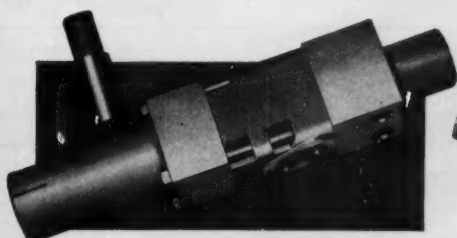
There are other advantages, too. Your engineering and manufacturing costs are substantially reduced since for all vehicle models you have a matching standard system. Your inventory is reduced because fewer parts are

needed and all parts are interchangeable... field service is simplified, speeded, too. These parts are all of the same well-engineered construction providing uniform performance and service.

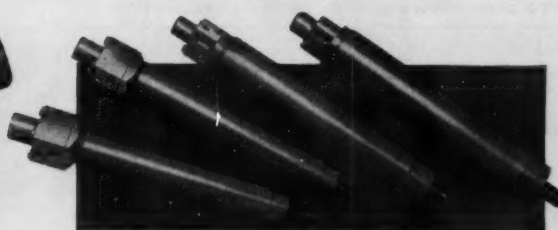
All cylinders are double walled eliminating functional damage to cylinder walls by flying debris, a common hazard.

In addition, when you deal with Vickers you are dealing with a pioneer in power steering... a company that maintains a staff of specialists in power steering to serve you. AND, you get the *complete* system from one source... Vickers, the name that *makes* the news in fluid power.

## FOR ANY VEHICLE HERE'S HOW SIMPLE IT IS



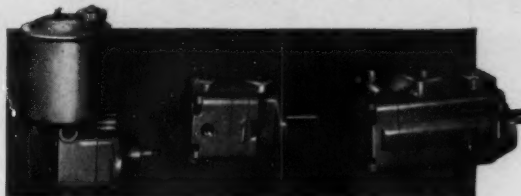
1. You take this **ONE** valve



2. One of **FOUR** cylinders



3. Connect them like this



4. Add one of three pumps

and you have **TAILOR-MADE VICKERS®**  
**POWER STEERING with STANDARD**  
**PRODUCTION-BUILT COMPONENTS**

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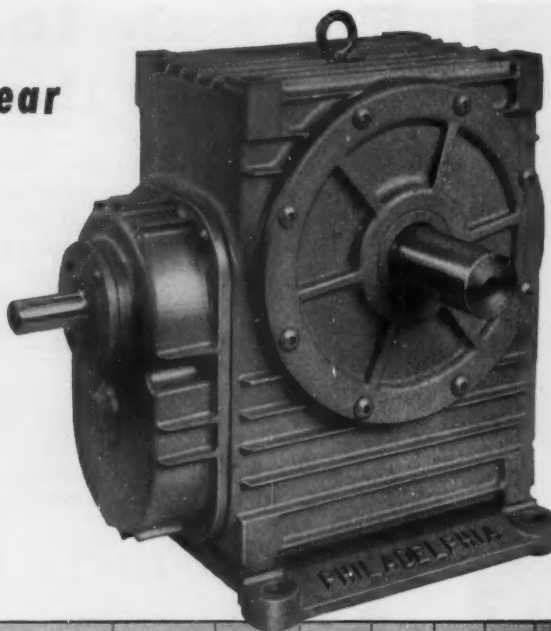
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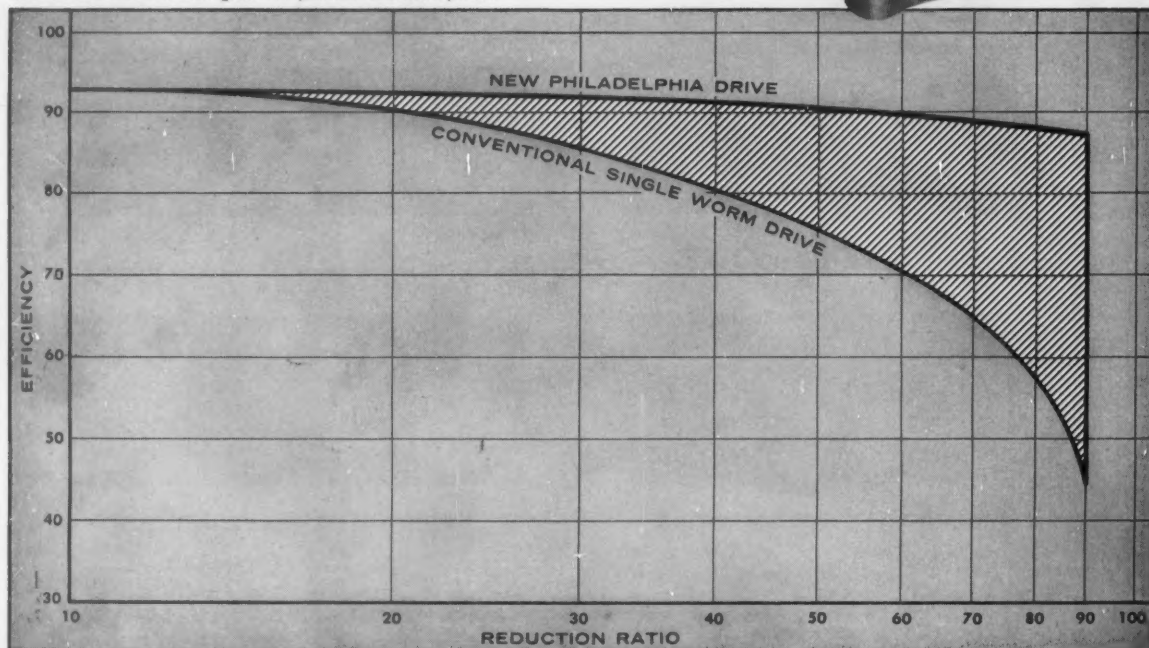
**NEW...from Philadelphia Gear**

## **HIGH EFFICIENCY WORM GEAR REDUCERS**

Now you can get increased efficiency in worm gear drives —see curve. Helical attachments for double and triple reduction units combine the efficiency advantage of helical gearing with the high ratio advantage of worm gearing. You save on power consumption . . . high operating temperatures will never be a problem.



Shaded area shows gain in power consumption



**New flexibility.** One basic housing design plus standardized mounting bases, gearing, helical attachments and torque control attachments permit fast assembly from stock. You can get *any* drive arrangement, *any* mounting arrangement, in the exact size and ratio to meet your specific requirements. Torque control attachments for all sizes are available from stock for applications demanding overload protection.

**New high capacity.** This is not just a re-rated line. Improved tooth forms, precision ground alloy steel worms, special high strength bronze gears, sturdy housings, helical attachments with ground gearing . . . all mean higher capacity in less space. In fact, you get space savings to 50% . . . weight savings to 60%. Ratios from  $5\frac{1}{2}$ : 1 to 1212: 1. Center distances from 3" to 21". Write for catalog data today.

# **philadelphia gear drives**

**PHILADELPHIA GEAR CORPORATION**

KING OF PRUSSIA (SUBURBAN), PENNSYLVANIA

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INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

**Experience—the added alloy in Allegheny Stainless**



## **HIGH TEMPERATURE ALLOYS YOU CAN WELD OR BRAZE LIKE STAINLESS**

In addition to their high strength characteristics, AM 350 and AM 355, A-L's precipitation hardening stainless steels, have other advantages for designers of missiles and supersonic aircraft.

When welding AM 350 and AM 355, there is little or no tendency to hot cracking or poor weld ductility, even in heavy sections. Both alloys weld as easily as the common stainless steels, even in the completely heat-treated condition. Brazability is equally easy—no special surface preparation is required during brazing operations.

Due to the high ductility in the annealed condition both alloys lend themselves to various kinds of fabrication—they can be spun, machined or formed using normal procedures.

In the heat-treated conditions, AM 350 and AM 355 have remarkable strength-to-weight ratio at both room and elevated temperatures, retaining useful strength and ductility up to 1000 F.

AM 350 is available commercially in sheet, strip, foil, small bars and wire. AM 355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars, wire, sheet and strip.

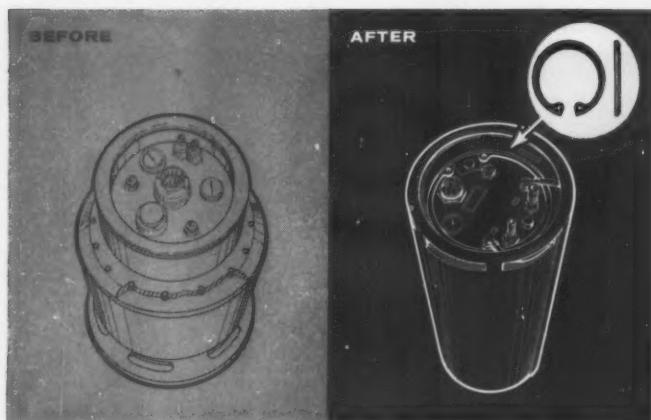
For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355." *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

002

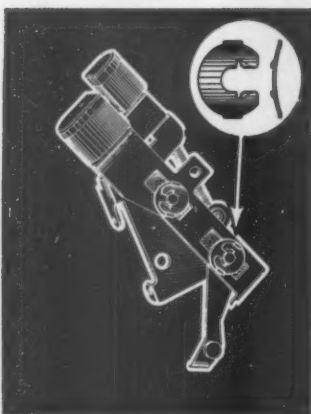
# **ALLEGHENY LUDLUM**

**EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT**

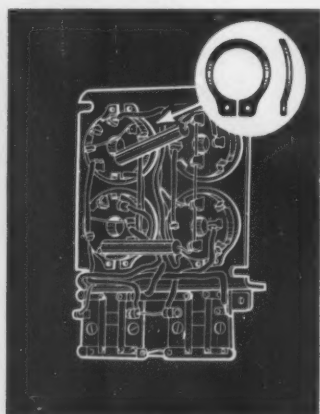




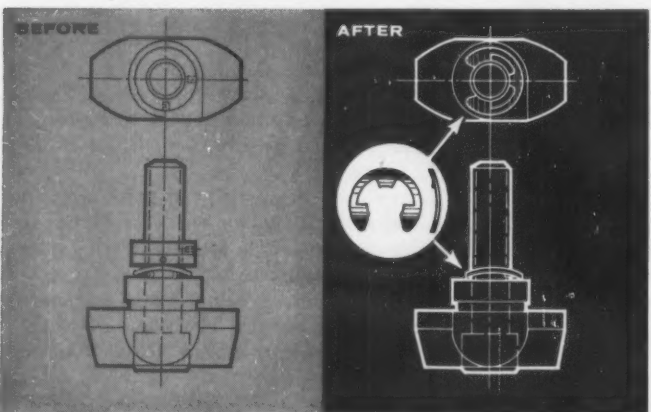
**Pressure cover design simplified.** Two axially assembled Truarc Series 5002 beveled rings eliminate 27 bolts, reduce machining and assembly time from 78 to 1½ hours and make possible drastic size and weight reductions. Rings retain two covers of a pressurized x-ray unit. Savings: about \$500 per unit.



**Parts eliminated in slide assembly.** Two radially assembled Truarc Series 5139 Prong-Lock® Rings provide proper spring tension, eliminate looseness and wobble in this office calculator shift-slide. Original design called for a cut washer, spring washer, and cotter pin—all eliminated.



**New way to install electron-tube sockets.** Easy-to-apply Truarc Series 5101 bowed external rings lock tube sockets to chassis plate in this assembly. Bowed construction takes up tolerances of molded grooves, thickness of base. Individual sockets are removable for field service.



**Quarter-turn clamp improved.** A bowed washer and two locknuts were eliminated in this quarter-turn jig-and-fixture clamp by a Truarc Series 5131 bowed E-ring. The radially assembled ring holds the screw captive, provides required rotational drag between parts with sufficient tension to insure tight fit when the screw is first engaged. Typical savings: \$1.35/unit—assembly up 70%.

## Truarc rings for end-play take-up offer significant design advantages

A number of Truarc retaining rings are available to take up end-play or loose fit caused by accumulated tolerances and wear. The rings often eliminate spring washers, collars and set screws, nuts, bolts, rivets, cotter pins and other conventional fastening devices with outstanding cost savings in machining and assembly time.

Truarc retaining rings designed to deal with the end-play problem are of two general types: bowed rings for resilient end-play take-up and beveled rings for rigid end-play take-up.

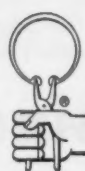
Bowed retaining rings are widely used for pre-loading bearings, preventing vibration or oscillation in linkages, providing tension on adjusting screws. Of particular interest is the radially installed Truarc Prong-Lock® ring which locks securely to the shaft by means of two prongs. It provides exceptional thrust load capacity, may be used as a shoulder against rotating parts, and often eliminates springs, bowed washers and other tensioning devices.

In beveled rings for rigid end-play take-up, the groove-engaging edge is beveled at 15°. There is a corresponding bevel on the load-bearing groove wall. To take up end-play, the ring acts as a wedge between the outer groove wall and the part being retained.

These are just a few of the 50 functionally different types of Truarc retaining rings. They come in up to 97 standard sizes, six metal specifications, 13 different finishes. The entire line as well as accessory assembly tools, grooving tools, and over 70 typical applications are shown in the new catalog RR 10-58. Write for your copy today. And remember Walde Truarc engineers are always ready to work with you on your specific projects. Walde Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N. Y.

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**WALDES  
TRUARC®  
RETAINING RINGS**

Walde Kohinoor, Inc., Long Island City 1, N. Y.

TRUARC RETAINING RINGS...THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS

# An open motor did what

**This Super-Seal motor** with *Poxeal* insulation and protected bearing was not fouled by mud. An Allis-Chalmers customer, in a frequently flooded area, required a motor that could readily start even after prolonged immersion in mud.

The "dirtiest mud available" was used in conducting the successful tests in the A-C Motor Laboratories.

**Motor user** requirements like this form the basis for A-C pioneer-leadership in motor development. Motor buyer needs *created the most complete line of integral-horsepower motors in industry*. Induction, dc, wound rotor, synchronous, gear, tube-type and *Synduction* motors, and now *Super-Seal* motors! And, if these lines don't fill your need, A-C engineering excels in special design.

**You can benefit** from this pioneer-leadership by contacting your A-C representative or distributor. For more information, write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

*Super-Seal, Poxeal and Synduction are Allis-Chalmers trademarks.*

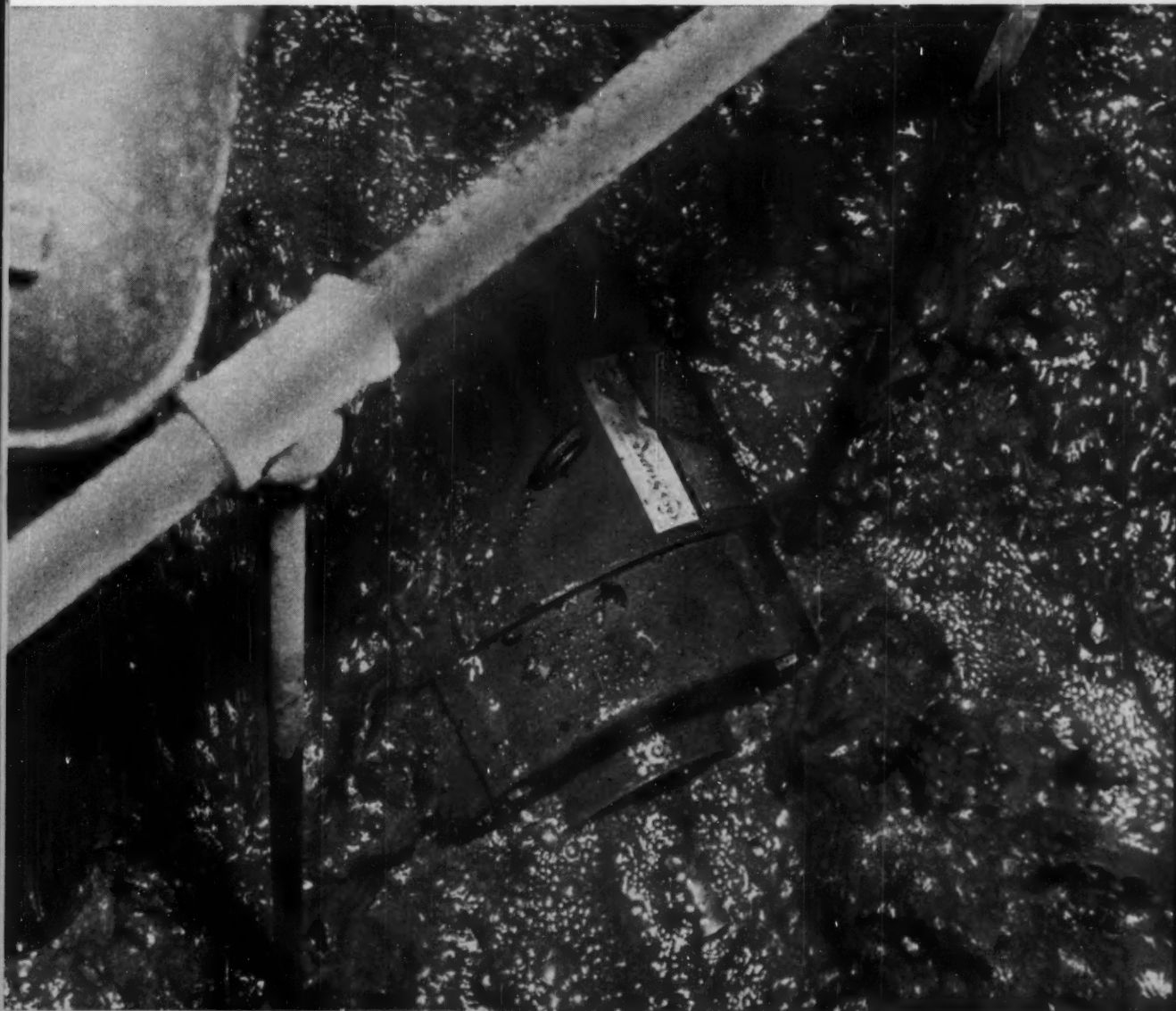
Circle 446 on Page 19

# no other motor could... in a mudbath

## ALLIS-CHALMERS

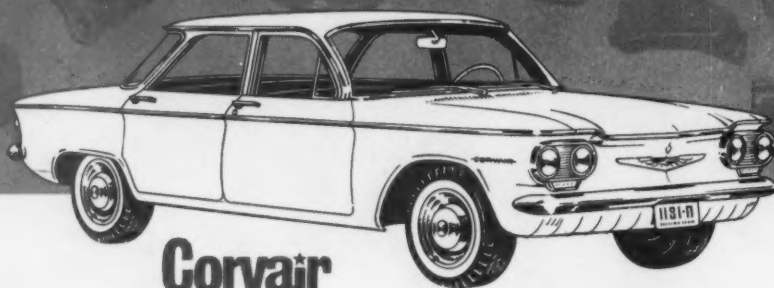


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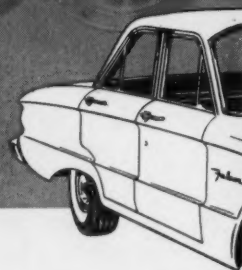


# Big Three's Little Three

to get Greater Strength  
for Maximum



**Corvair**



*Falcon*

Each time a trio of these new cars rolls off the assembly lines at Ford, Chrysler Corporation and Chevrolet, another set of 67 Malleable parts goes into action to give American drivers more dependability, convenience and economy.

## **Valiant, Corvair and Falcon Use Greater Proportions of Malleable Iron Than the Three Conventional Cars!**

Brand new from tread up, the Corvair, Falcon and Valiant are the result of intensive investigation, engineering and testing . . . all done to produce lighter,

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*To accomplish this, the automobile industry's*

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Operating Economy....



Valiant

three newest creations use *more* Malleable in proportion to total materials than all other models of the same manufacturers. Why? Malleable provides *more strength per dollar* than any other metal, ferrous or non-ferrous. Malleable castings have *more strength per pound* than "light" metals. Being the *most machinable of all ferrous metals* of similar properties, Malleable speeds production . . . produces better parts. Malleable castings have proved uniquely dependable for critical applications in millions of cars now on the highways.

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## Flash butt-welded ring from extruded material slashes away 64 lbs. of stainless 310

Only 1/3 as much material was required when a special extruded section was substituted for bulky bar stock in this flash butt-welded ring. By leaving 2/3 of the material at the mill, instead of hogging it out, Amweld saved its customer \$76.83 per ring—plus hours of expensive machining. (Savings compared to the forgings originally used are even greater.)

Amweld is equipped to supply flash butt-welded rings and circular products in stainless, titanium, aluminum, as well as a wide variety of corrosion-resistant alloys. If you would like to know more about Amweld's welding, fabricating and complete machining facilities, phone or write.

**AMWELD**® INDUSTRIAL PRODUCTS

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO



### GET THE FACTS ABOUT AMWELD

New 20-page catalog describes flash butt-welded rings and circular products manufactured by Amweld. Also booklet entitled, "How Flash Butt-Welded Rings are Made."

# Logan's

# 44<sup>th</sup> year...

## ...of uninterrupted service to industry

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*providing you with maximum  
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**Logan**... world's largest manufacturers  
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OVER 11,000 STANDARD CATALOGED ITEMS;  
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# GEAR-O-MATIC

## INSTANT-REVERSING MOTOR

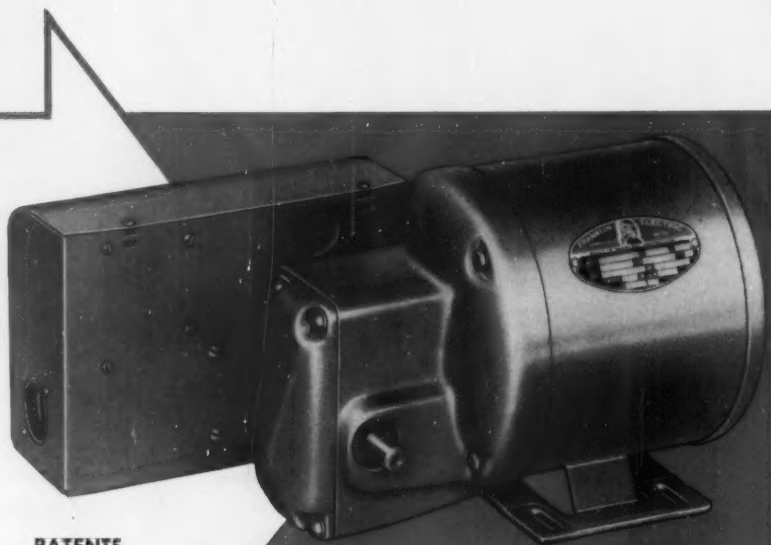
DEPENDABILITY for stop-go, forward-reverse motion with full power, high-torque start. Operable manually, by built-in limit switches, or as automation requires. SAFETY assured with automatic, instant reversal when driven product meets predetermined resistance. ECONOMY as a low cost packaged operator unit ... quick and easy to install or integrate with your product or system.

### POWER-FULL GEAR REDUCTION

Worm gear drive from capacitor-start Franklin Electric Motor applies full power instantly upon reversing at built-in limit switch setting.

Driven system or product may be instantly reversed at any time during forward or reverse cycle by manual or automatic switch; or by automatic operation of built-in safety device.

GEAR-O-MATIC® performs all functions typically required in radio-controlled or manual-switch garage door operation ... functions applicable to operation of many other products ... perhaps yours.



PATENTS  
PENDING

Integrated with the Franklin Electric Motor is a control box with 24 volt A. C. circuitry. System includes plug-in connection for radio or automation control and receptacle for light bulb or power extension line. All limit and safety reversing switch settings are adjustable.

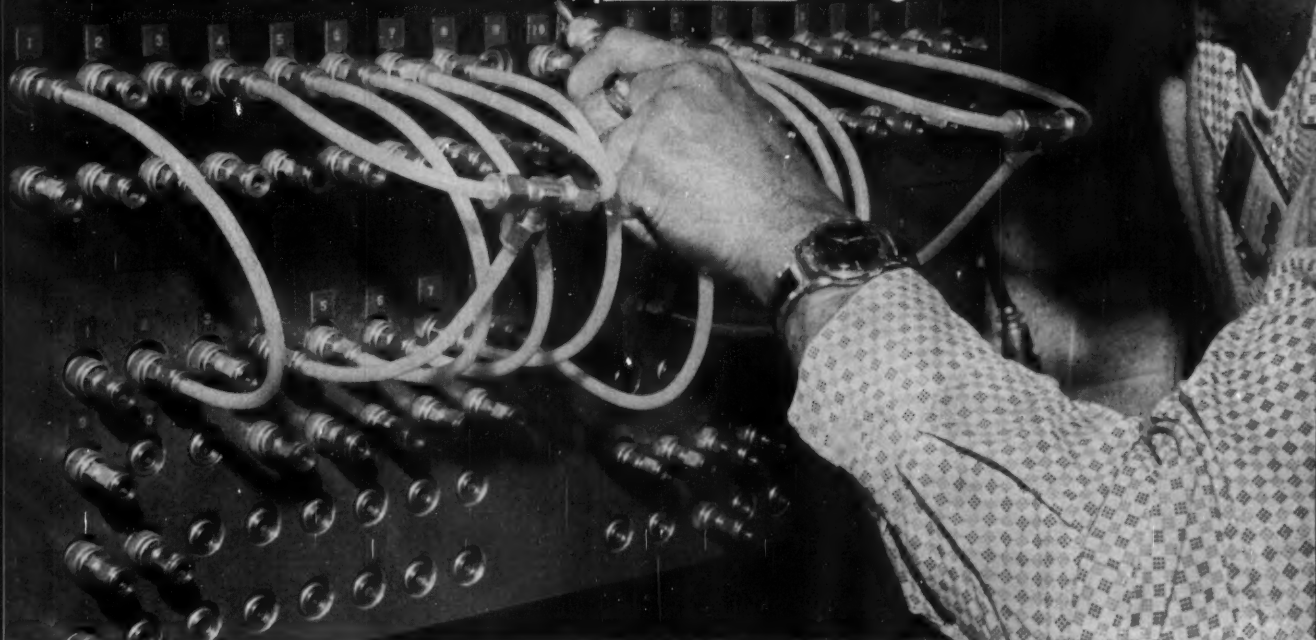
From the  
Home of  
DEPENDABLE  
Electric  
Motors

For more data write for  
"FACTS ABOUT FRANKLIN  
GEAR-O-MATIC®"



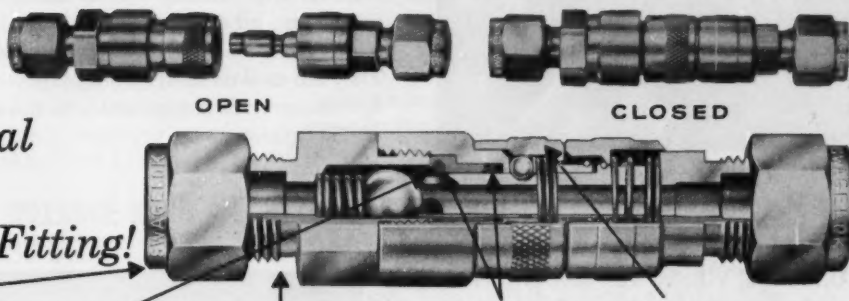
**Franklin Electric Co., Inc.**  
BLUFFTON, INDIANA

## What's the secret of this fast, positive-seal fitting?



Swagelok Quick-Connect Fitting Installation in Boeing Airplane Company, Seattle, Wash., Test Facilities for Boeing 707 Jet Stratoliner.

*Here's the  
secret of this  
fast, positive-seal  
Swagelok  
Quick-Connect Fitting!*



1. Swagelok Quick-Connects with single end or double end shut off for tube to pipe, tube to tube, bulkhead tube to tube applications are available in brass and stainless steel in sizes for  $\frac{1}{8}$ " and  $\frac{1}{4}$ " O. D. tubing.
2. Flow resumed instantly and vacuum tight seal assured when connection is made.
3. Light, compact, streamlined design. Occupies little space. For use with portable equipment, and bulkhead or panel applications.
4. Instant-acting seals completely prevent loss of pressure when fitting is disconnected.
5. No twisting, turning or wrench action necessary. Easy straight-line finger tip pull or push action for instant connecting or disconnecting.

In the Boeing Airplane Company photo shown above, the tubes are instrumentation pressure lines running from the large jet engines on test stands to the patch board, where the lines are coupled into measuring devices.

The Boeing Airplane Company adopted this positive

Swagelok Quick-Connect Fitting to simplify test installations, and substantially cut down test set-up time. Both ends of the many pressure lines are Swagelok-equipped. Previously, engineers used a screw-type fitting which required a wrench and valuable time-consuming operations to tighten and remove.

Swagelok engineers are equipped with experience, ability, and a wide range of tube fittings designed to meet your individual problems. Quick delivery of Swagelok tube fittings from local distributor stocks.

**Swagelok®**  
TUBE  
FITTINGS

**CRAWFORD FITTING COMPANY**  
884 East 140th Street • Cleveland 10, Ohio  
Crawford Fittings (Canada) Ltd., Niagara Falls, Ontario, Canada



TRANSMISSION BELTS from the Power Unlimited complete belt line

# POWER UNLIMITED...

U. S. Rubber's research, development and manufacturing facilities all combine to produce Endless Transmission Belts that fulfill every Power Transmission need. For example:



## U.S. **PowerGrip** "TIMING" BELT

These belts, invented by "U.S." research and manufactured by the "U.S." unparalleled facilities (in the only plant in the industry devoted exclusively to the production of endless transmission belts), are patented products. They were acclaimed by the Franklin Institute of Philadelphia the greatest power transmission belt invented in this decade.

PowerGrip "Timing"® Belts never stretch. They require no lubricating or maintenance. Operating without tension, they prolong the life of bearings. They are used on drives from fleapower to 1,000 hp. Speeds are from imperceptible to the eye and up to 16,000 f.p.m.

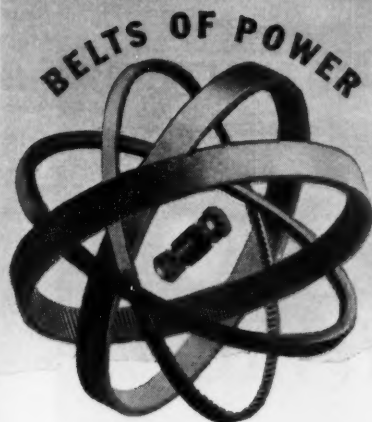
## U.S. ROYAL V-BELTS

U.S. Royal V-Belts, with 40% greater h.p., are made by entirely advanced automation and curing processes.

They are without question unequalled for service on multiple transmission drives. Their *length-stability* makes this an undisputed fact. This has been proven in actual plant use in all parts of the country—on the West Coast (Ranchers Cotton Oil Co., Fresno, Calif.), the East Coast (The Ruberoid Co., Gloucester City, N. J.) and in a New England paper-making plant, to point out a few. Any U.S. Royal V-Belt will continue to pull its full share of the load long after one or more of the belts on an ordinary set have given up.

The length-stability of U.S. Royal V-Belts saves you dollars in Time and dollars in IN-VENTORY.

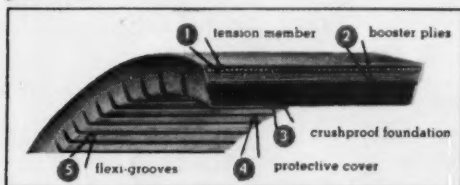




## the only complete line of Transmission Belts

### PRESS-CURED V-BELTS

The U. S. Royal line, of course, includes sizes larger than 180". These giant size V-belts are built by a new "U. S." process that practically eliminates length variation and greatly reduces belt matching problems.



### VARIABLE SPEED BELTS

This Belt is non-squash, non-sag. This is the belt to do away with Variable Speed Belt problems. Hard, rigid rubber encloses soft rubber containing tension members. The *exclusive* and complete rigidity in these belts prevents squashing.

In plant after plant, users find that lengthwise stretch is just about non-existent. *No sagging*. This belt has complete accuracy regardless of speed changes—whether you switch from 2,000 rpm to 10.

### U.S. ROYAL SPEEDAGE KORD ENDLESS BELTS

The U. S. Speedage Kord® Endless Belts are for really high-speed service—up to 18,000 f.p.m. Thin enough to operate over pulleys as small as  $\frac{1}{2}$ " in diameter. Designed for work on open, serpentine and reverse drives. No seams, splices or laps to cause vibration. Available from stock in a wide range of popular sizes.

### SPINNER BELTS

This belt will travel up to 113 mph with no vibration, *no noise*. The reduction in the length of modern spinning machines requires a belt of this high speed. Special "U. S." construction methods make possible building of belt with a minimum of splices, regardless of length. Contamination of yarn is prevented by another unique feature: no rubber on outside surfaces. The belt for uniform twist and smooth spindle operation.

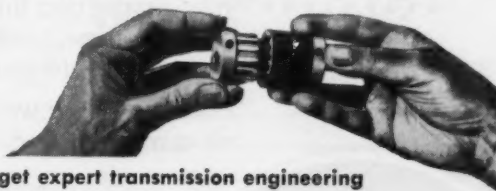
### U.S. ROYAL FLAT BELTS

U. S. Spinner Belts are only one type of belt in the U. S. Complete Flat Belt line. "U. S." produces a variety of belts for a multiplicity of services. They each feature a specially woven duck for top strength and tenacity with top-quality friction between plies.

### U.S. FLEXIBLE COUPLINGS

Misalignment, whether angular, axial or lateral, is compensated for by this coupling, most versatile ever produced. It provides torsional resilience by angular displacement and insulates both vibrationally and electronically (no metal-to-metal contact).

Design of this coupling is so free of complicated parts that cost is truly low in comparison with other couplings. It will pay you to insist on having these tried on your machinery. The result will be a very desirable reduction in maintenance costs.



The one and only sure way to get expert transmission engineering service is through your U. S. Rubber Transmission Distributor. He stocks the *only complete transmission belt line*. He never attempts to make one type of belt perform where another type should be used. He is unbiased in seeing that you get the right belt for your needs.



Mechanical Goods Division

# United States Rubber

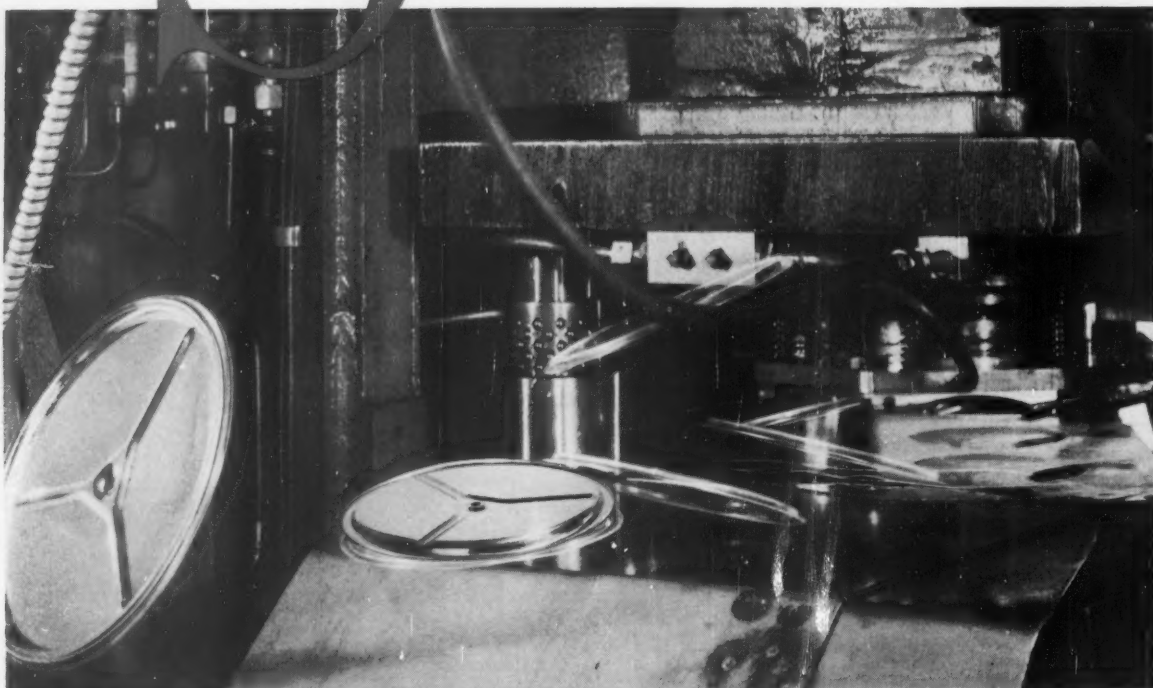
WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y.

In Canada: Dominion Rubber Company, Ltd.

Circle 452 on Page 19

# S is for *SPEED* and *SERVICE*



S  
.....

Savings and service are the prime products of speed. As units-per-hour go up, cost-per-piece comes down.

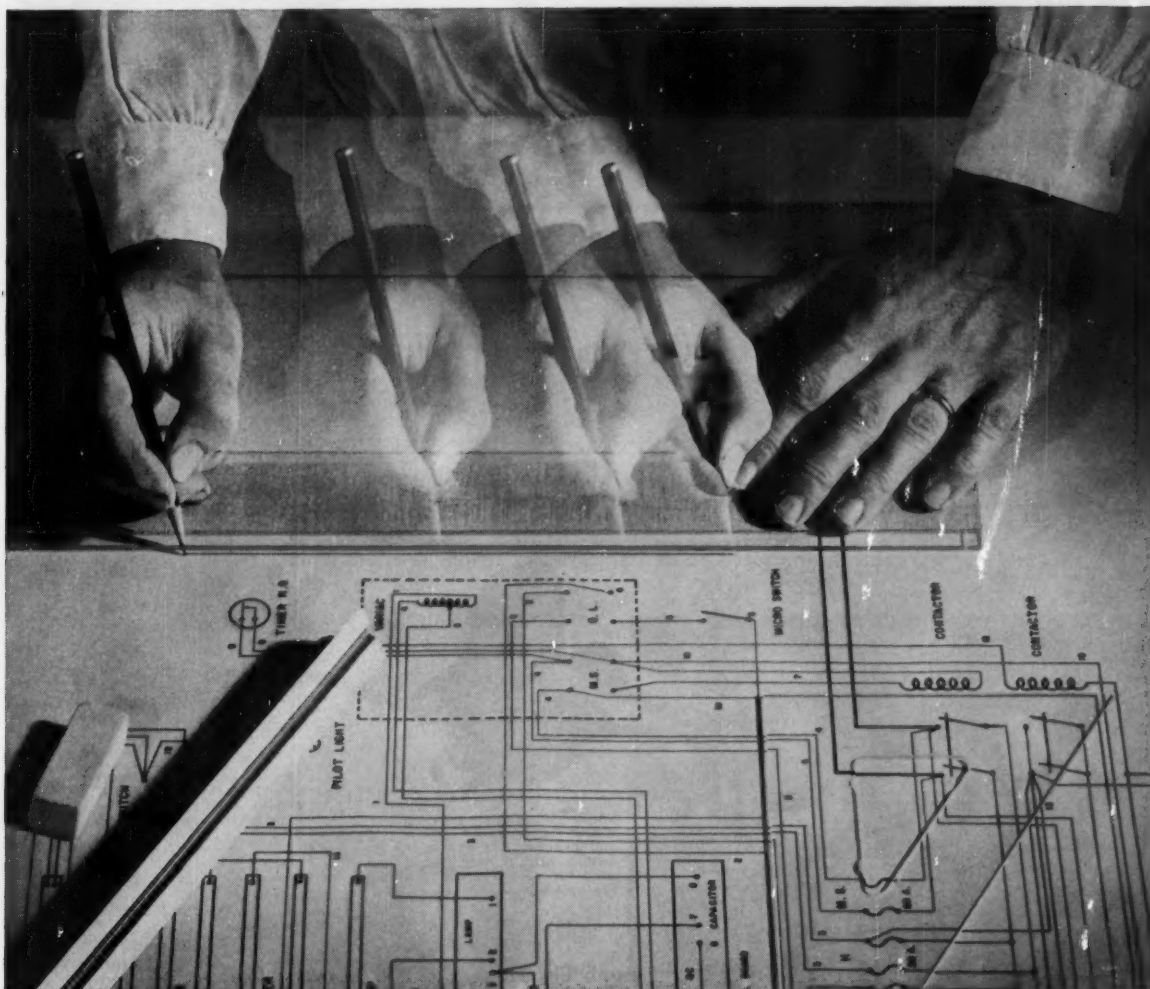
Here, high-speed, automatic equipment saves money for you, as it eats up aluminum sheet and machine-guns a flow of finished components into your production line. Schedules are met and shipments made, *on time*, because of our awareness of the importance—to you—of speed.

Phone, wire, or write for more information about how we can help you do *your* job faster, for less.



MIRRO ALUMINUM COMPANY • MANITOWOC, WISCONSIN • Fifth Avenue Bldg., New York 10 • Merchandise Mart, Chicago 54

# CRONAFLEX\* DRAFTING FILM... BEST SURFACE YOU CAN USE



"Best surface" is a broad statement. But you can prove it to yourself by mailing the coupon below; we'll send you a sample of CRONAFLEX Drafting Film for testing.

It's best for several reasons: it's the only drafting film that's made by one manufacturer—Du Pont—from start to finish. This means that CRONAFLEX Drafting Film is consistently superior, because we control every manufacturing step. CRONAFLEX Drafting Film is an exclusive combination of an outstanding surface on Du Pont's tried and proven CRONAR\* polyester film base.

**The surface:** ideal for pencil... erases easily... smear-resistant... clearer than cloth... you get faster print-through speed with greater uniformity... accepts recommended inks.

**The base:** holds size... flexible... unexcelled strength... moisture-resistant... easy to handle (.004" thickness)... lies flat.

CRONAFLEX Drafting Film is available matted one or two sides, in rolls or sheets.

Find out for yourself how good this new product really is. Just mail the coupon, and we'll send you some literature and a test sample.

Du Pont Photo Products  
2432-A Nemours  
Wilmington 98, Delaware

MD-2

Please send me more information about CRONAFLEX DRAFTING FILM, and a test sample.

NAME \_\_\_\_\_  
COMPANY \_\_\_\_\_  
STREET \_\_\_\_\_  
CITY \_\_\_\_\_ STATE \_\_\_\_\_



Better Things for Better Living... through Chemistry

\*Du Pont registered trademarks

This advertisement was prepared exclusively by Phototypography

motors like these  
help your product  
**STAY AHEAD**  
of competition...



Lamb® induction gearmotor with special quiet operating three-stage gear train and magnetic brake for rotary office file. Frame 4½ x 2¾.

Lamb® four-pole split phase motor with resilient cradle base for business machines. Frame 4½ x 2¾.

Lamb® six-pole 400 cycle AC motor for operation submerged in jet fuel for booster pump drive. Frame 2¾ x 2½.

Lamb® three-stage gearmotor incorporates special brackets, reversing switch and connecting cord for pipe threader. Frame 4¾ x 2¾.

Lamb® series motor with two-stage fan — the standard for high performance domestic canister-type cleaners.

Lamb Electric works in so many fields — where motors that have vastly different jobs to do are sold to vastly different markets — that experience gained in one field often helps solve problems in other fields.

For example, we are able to incorporate in motors for appliances, portable electric tools, and similar products, developments that came about in research and engineering work on military and other precision motors.

This broad experience — available to all of our customers — is one way in which Lamb Electric special application motors can help your product stay ahead of competition.

Let us demonstrate the value of this experience in bringing to *your customers* improved products and to *you* more business and better profits.

**THE LAMB ELECTRIC COMPANY • KENT, OHIO**

A Division of American Machine and Metals, Inc.

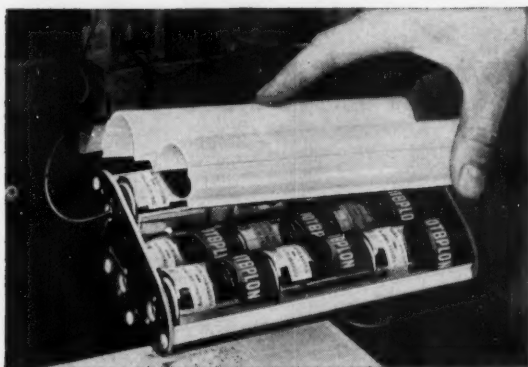
In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario



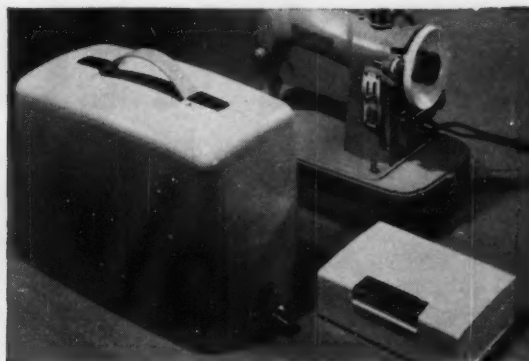
**WRITE FOR  
YOUR COPY**

8-page folder describes  
these and other Lamb  
Electric motors.

**Lamb Electric**  
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**



**1** Extruded from styrene, this transistor radio's battery case:  
 (a) cushions vibration (b) prevents short circuits  
 (c) keeps batteries dry



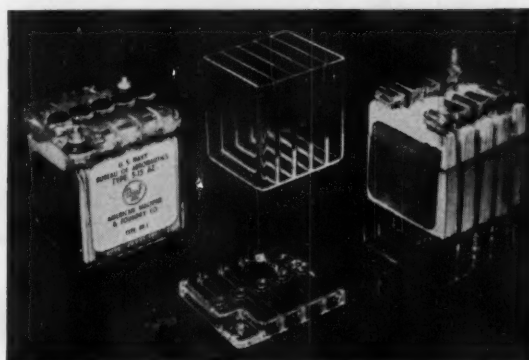
**2** Molded of high-impact styrene, this case is notable for its:  
 (a) injection-molded depth (b) strength to carry a 25-lb. load  
 (c) colorful gleaming surface

## Can you pass this test on Styrene Plastics?

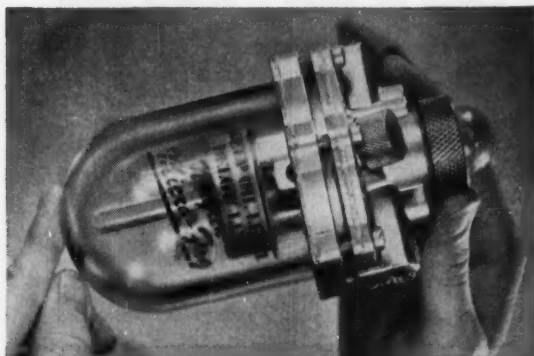
(You'll discover more of their potential as design materials)



**3** Refrigerator door panels are fashioned of styrene for:  
 (a) impact strength (b) insulation  
 (c) lower material cost



**4** It's a silver-zinc battery's case, molded of C-11 styrene for:  
 (a) transparency (b) resistance to potassium hydroxide  
 (c) production economy



**5** This molded C-11 oil sight-bowl withstands pressures up to:  
 (a) 1200 psi (b) 30 psi  
 (c) 250 psi

### ANSWERS... to engineering and styling needs are found in BAKELITE styrene plastics.

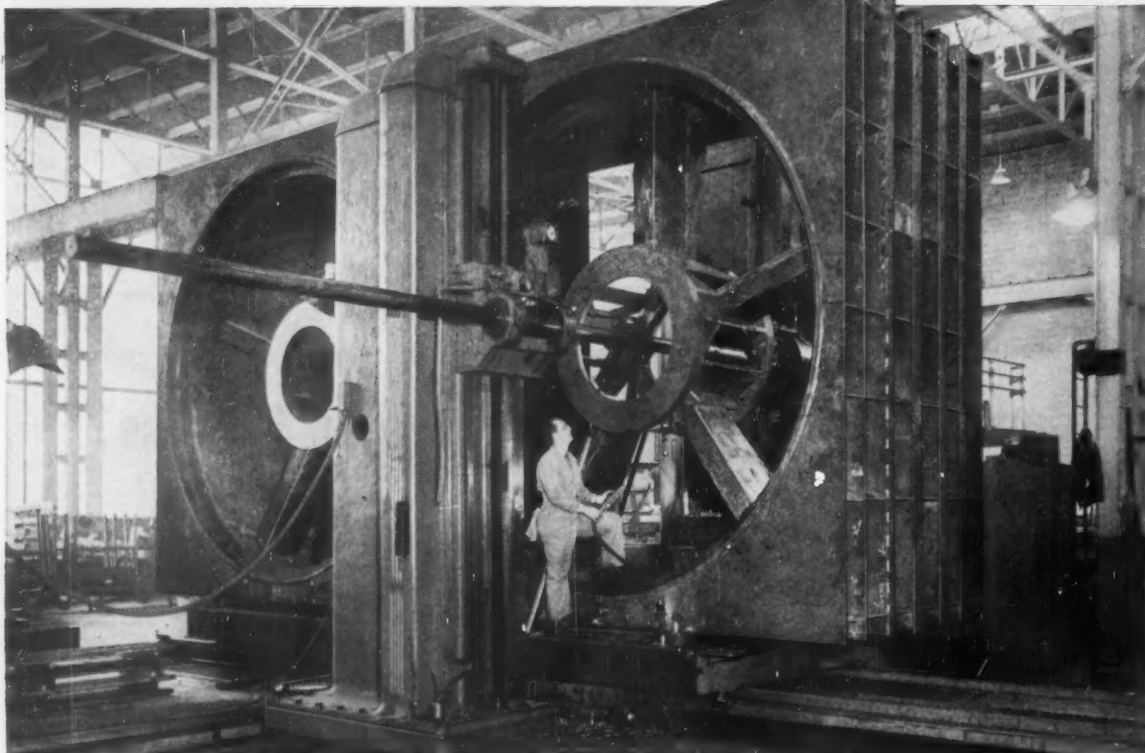
1. (b) Prevents short circuits. It keeps wiring from metal battery case.
2. Check (a), (b) and (c), but emphasize its deep, one-piece molding.
3. (a), (b) and (c) plus color variety.
4. (b) is most important, but (a) and (c) are advantages, too.
5. (a) Believe it or not—1200 psi!

**If you have questions**—about designing with plastics for function, serviceability, economy and appearance—please ask us. We'll be glad to answer on the practical design and engineering uses of vinyls, epoxies, phenolics, styrenes, and polyethylenes. Just write or call any of our offices or write Dept. BW-640, Union Carbide Plastics Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto 7.



"Bakelite" and "Union Carbide" are registered trade marks of Union Carbide Corporation.

# STEEL-WELD FABRICATION...



## PRECISION WELDMENTS

### Fabricated and Machined to Specification!

The two weldments illustrated above are wind tunnel sections designed with motor mounts to house giant propellers driven by electric motors. These husky pieces are typical of thousands of Steel-Weld Fabricated parts and assemblies produced and machined by Mahon for defense contractors and manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment.

When your design calls for weldments of any kind, you, too, will want to discuss your requirements with Mahon engineers; because, in the Mahon Company you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with a long and enviable performance record, and unusual facilities for design engineering, fabricating, machining and assembling.

*See Sweet's Product Design File for information on Facilities, or have a Mahon sales engineer call at your convenience.*

THE R. C. MAHON COMPANY • Detroit 34, Michigan  
SALES-ENGINEERING OFFICES in DETROIT, NEW YORK, CHICAGO, LOS ANGELES and SAN FRANCISCO

Use WELDED STEEL for  
100% Predictability  
and Greater Strength  
with Reduced Weight!

# MAHON



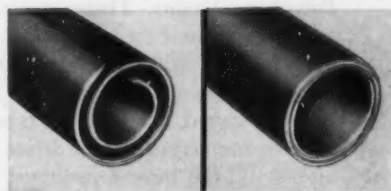
## Bundy can mass-fabricate practically anything

... with Bundyweld®—double-walled steel tubing that is adaptable to a whole host of applications.

**W**HATEVER your tubing problems . . . whatever the stage of development of your product, the Bundy man awaits your call. That's because tubing problems are Bundy's business, and Bundy engineers—with years of tubing experience—can often come up with a design angle that'll save you time and money.

But the Bundy service doesn't end there! Specially designed Bundy machines take over the mass-fabrication of these parts in unlimited quantity. And to meet rigid specifications, we use Bundyweld—the original double-walled steel tubing—the safety standard in small diameter tubing. Thinner-walled Bundyweld is stronger and gives you higher bursting and fatigue strengths. Covered by Government Spec. MIL-T-3520, Type III.

Why not bring your tubing troubles to Bundy and take advantage of expert engineering and design, mass-fabrication economies, and Bundyweld tubing? See Sweet's Product Design File 1e/Bu . . . or write directly for full information! Bundy Tubing Company, Detroit 14, Michigan.



Bundyweld is the original tubing double-walled from a single copper-plated steel strip, metallurgically bonded through 360° of wall contact for amazing strength, versatility.

Bundyweld is lightweight, uniformly smooth, easily fabricated. It's remarkably resistant to vibration fatigue; has unusually high bursting strength. Sizes up to ½" O.D.

*There's no substitute for the original Bundyweld Tubing*

# **BUNDY® TUBING COMPANY**

HOMETOWN, PA. • DETROIT 14, MICH. • WINCHESTER, KY.

WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, BRAZIL, ENGLAND, FRANCE, GERMANY, AND ITALY

## Wagner Vertical Solid Shaft Motors...

# POWER PACKED PUMP DRIVES



Got pump-power problems? You can solve them—simply, easily—with Wagner Vertical Solid Shaft Polyphase Motors. These motors are designed especially to meet the load conditions of pumping. They handle loads without laboring or stalling... are smooth running under cyclic loads. They are uniquely suited, too, for other types of equipment that require vertical motor drives. Match them to agitators, axial fans, centrifuges, mixers, presses... anywhere you need a vertical shaft motor.

Whatever the application, one thing is sure... Wagner advanced design engineering has produced vertical shaft motors of simple, rugged cast-iron construction... motors with plenty of stamina to give you economical, maintenance-free service the year 'round, indoors or out.

Wagner Vertical Solid Shaft Motors are end-mounted, squirrel-cage type with NEMA Type "P"

base. They are available in standard ratings of 60 cycle, 208-220/440 and 550 volt, 1½ through 40 hp—3500 RPM, and 1 through 30 hp—1750 RPM. For information on larger horsepower ratings, call your nearby Wagner Sales Engineer.

Other motor requirements? Wagner can supply standard motors or build special motors to fit your needs. More than 65 years of constant research and development in electric motor design has made Wagner a name you can depend on. For an analysis of your next motor application, be it for plant or product call on Wagner. There are 32 branch offices in principal cities across the country.

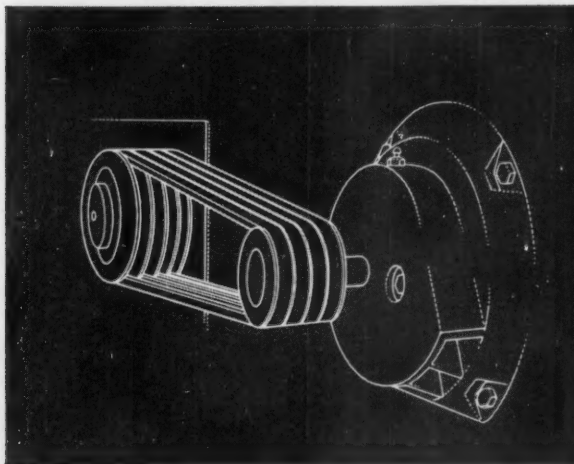
**Wagner Electric Corporation**

6404 Plymouth Ave., St. Louis 33, Missouri

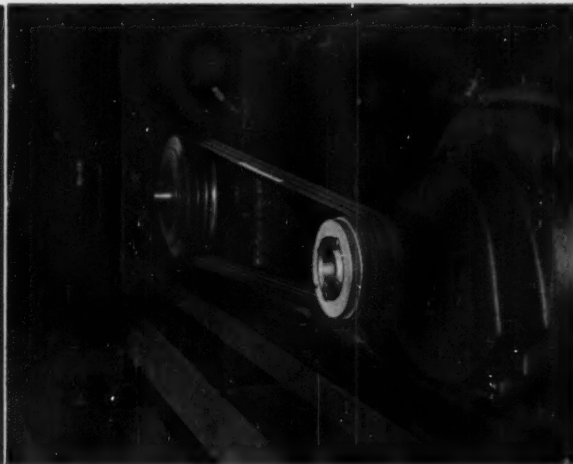
WH60-4

SERVING 2 GREAT GROWTH INDUSTRIES — ELECTRICAL — AUTOMOTIVE

**BEFORE:** This drawing of the former 4-belt drive on a clothes pressing unit is in the same scale as the photo of new Super HC V-Belt Drive at right. Heavy sheaves needed for 4 belts imposed high bearing loads.



**AFTER:** By redesigning the drive for Gates Super HC V-Belts only 3 belts are required and this Utah manufacturer saves 16 pounds in weight and 24% on the drive cost of every pressing unit it makes.



## Manufacturer of pressing equipment cuts cost of drives 24%

### New high capacity V-belt also saves weight and space!

This manufacturer is just one of many who have already turned to Gates Super HC V-Belts to achieve far more compact, lighter weight, lower cost V-belt drives for all types of machines. With new Super HC

V-Belts, sheave dimensions can be reduced 30% to 50%, overall space up to 50%, and drive weight by 20% and more.

A product of Specialized Research in the world's largest V-belt laboratories at Gates, the Super HC V-Belt Drive is already standard equipment on production models in virtually every industry.

### Engineering Service Nation-Wide

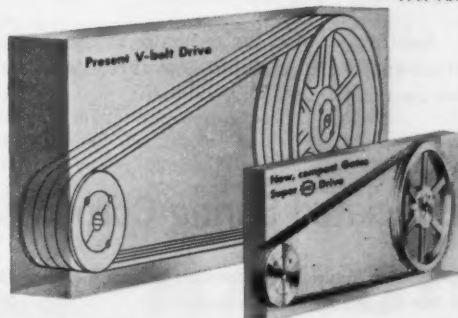
Whatever your plant's power transmission design problem, wherever you are, your nearby Gates Distributor or Field Representative is ready

to assist you to cut space, weight, and costs with Super HC. Ask him for a copy of *"The Modern Way to Design Multiple V-Belt Drives."*

**The Gates Rubber Company, Denver, Colorado**  
**Gates Rubber of Canada Ltd., Brantford, Ontario**



World's Largest Maker of V-Belts

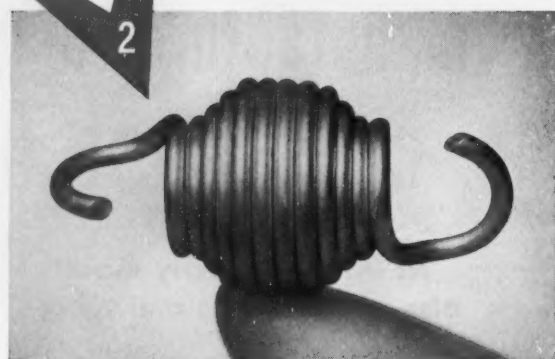
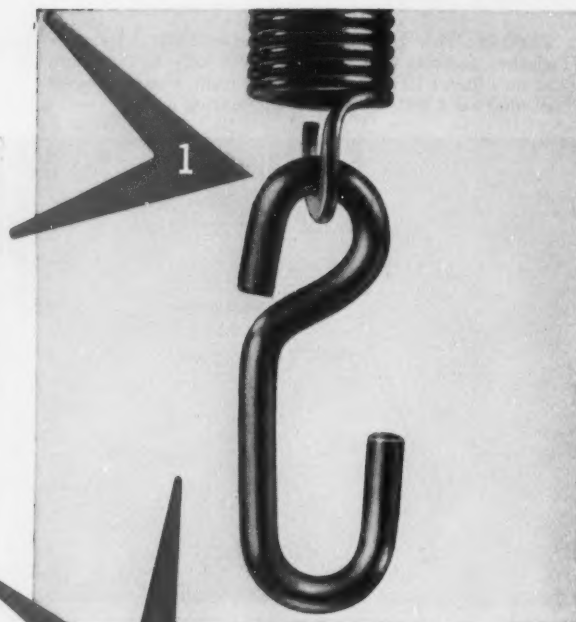
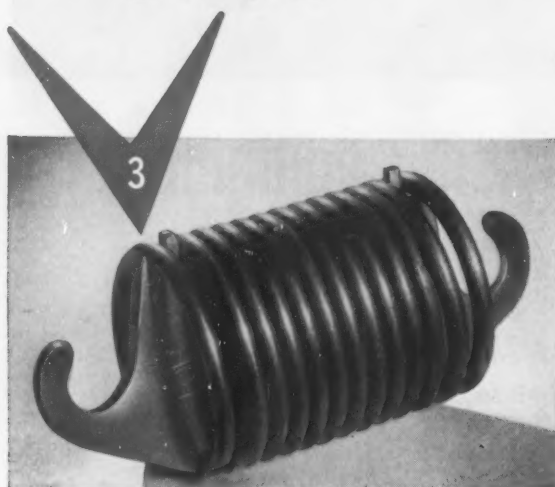


TPA 463

# Gates Super V-Belt Drives

same hp capacity  
in smaller "package"

# Why it pays to look at the end in the beginning



1. In this pick-arm spring for a textile machine, natural frequency vibration plus rigid end restraint caused early failure. By redesigning spring and adding swivel hook to end assembly, failure was avoided and cost reduced as well.

2. Fatigue failure caused by bending stresses occurs where end hooks join working coils. In this method of reducing the combined stress, two coils at each end are wound with a reduced diameter.

3. Another method for reducing stress concentration where end hooks join coils is to thread a flat stamping into end coils.

Here are a few examples of why it pays to call on the springmaker early in your design problems. End-hook failure of extension springs is a common occurrence that experience can help avoid. Check your specifications for performance and production economy by consulting an A.S.C. spring engineer. Write for bulletin "How to Solve Your Spring Design Problems."

## Associated Spring Corporation



General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.  
B-G-R Division, Plymouth and Ann Arbor, Mich.  
Gibson Division, Chicago 14, Ill.  
Milwaukee Division, Milwaukee, Wis.  
Canadian Subsidiary: Wallace Barnes Co., Ltd., Hamilton, Ont. and Montreal, Que.

Raymond Manufacturing Division, Corry, Penna.  
Ohio Division, Dayton, Ohio  
F. N. Manross and Sons Division, Bristol, Conn.  
San Francisco Sales Office, Saratoga, Calif.

Seaboard Pacific Division, Gardena, Calif.  
Cleveland Sales Office, Cleveland, Ohio  
Dunbar Brothers Division, Bristol, Conn.  
Wallace Barnes Steel Division, Bristol, Conn.

Puerto Rican Subsidiary: Associated Spring of Puerto Rico, Inc., Carolina, P.R.



*thanks to* **XEROGRAPHY...**

## A Stock-Print System Saves You Up to \$50,000 Yearly

You can save \$50,000 or more a year by installing a stock-print system of engineering drawings. Cutler-Hammer Inc. of Milwaukee is achieving such an economy. So is

Arma division, American Bosch Arma Corporation, Garden City, N. Y.

A stock-print system is a streamlined library of engineering drawings commonly in use. The library is unattended. Anyone who wants a drawing helps himself. There are no requisition forms, no waiting, no re-filing. Prints are so inexpensive that engineers are urged to discard them after use.

What makes such efficiency... and such seeming extravagance... possible?

The answer is xerography and offset duplicating. Xerography is a clean, fast, dry, electrostatic copying process that within seconds reduces original drawings as large as 34" x 44" onto inexpensive offset paper masters. From them, multiple copies are run off on an offset duplicator.

There is a wide range of Xerox® copying equipment for setting up an efficient stock-print system. Your reproduction needs determine the xerographic model best suited to you. All models—besides prepar-

ing offset paper masters—make copies on plain, unsensitized paper or translucent velum for diazo-type reproduction.

All models—whether manual or automatic—enlarge, reduce, or copy size to size. They offer the fastest, most versatile, most economical way to get sharp, clear copies from original documents of all kinds or from microfilm.

Write for proof-of-performance folders showing how companies of all sizes are speeding paperwork duplicating and saving thousands of dollars yearly by xerography. HALOID XEROX INC., 60-110X Haloid St., Rochester 3, N. Y. Branch offices in principal U. S. and Canadian cities. *Overseas:* Rank-Xerox Ltd., London.

# HALOID XEROX®

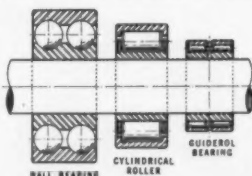


**PUSH THE BUTTON  
and copies flow!**

# McGILL®

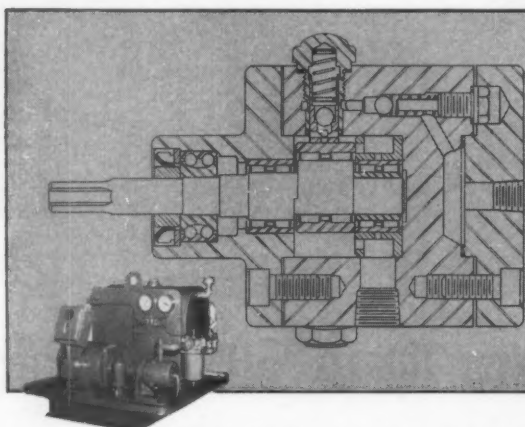
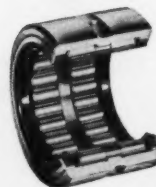
## GUIDEROL® bearings offer higher load

GUIDEROL bearings pack more high capacity performance into smaller radial space. Their construction features the extra capacity of a full complement needle bearing and effective roller control. Center guided rollers limit skewing and prevent binding under adverse conditions in either horizontal or vertical mountings. For a common 1" shaft, the GUIDEROL bearing has an O.D. of only 1½" with a capacity of 6310 lbs. Compared to a cylindrical type roller bearing, the GUIDEROL bearing requires ⅜" less housing space and offers 23% more capacity. A ball bearing for the same shaft uses almost an inch larger O.D. to carry 1500 lbs. less radial load. Space-saving GUIDEROL bearings simplify design and cut housing space requirements. Available with or without inner rings in shaft sizes from ⅜" to 9¼" with capacities ranging from 2880 lbs. to 128,670 lbs. (at 100 RPM).



### Sealed Guiderol Bearings Protect Performance Life and Cut Maintenance

Pre-lubricated and sealed GUIDEROL bearings lock lubrication in and seal contamination out. Interchangeable dimensionally with GUIDEROL GR Series bearings, they cut maintenance in two ways. Bearings last longer and frequent re-lubrication is not required. 5 different seal combinations are available to fit specific mounting requirements.

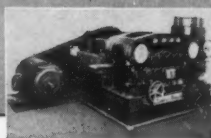
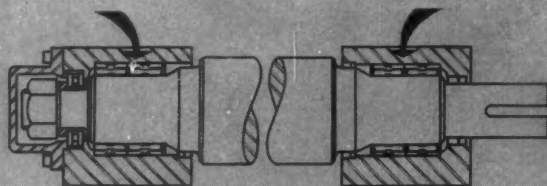


### SIMPLEX ENGINEERING USES GUIDEROL BEARINGS IN HIGH PRESSURE HYDRAULIC PUMPS

The SECO "LA" Series pumps, shown in cross section above, are fixed displacement seven piston radial pumps, utilizing unique patented principles which enable them to generate pressures as high as 10,000 PSI without loss of mechanical efficiency. SECO pumps are manufactured by the SIMPLEX ENGINEERING COMPANY, a subsidiary of RACINE HYDRAULICS & MACHINERY, INC.

MCGILL GUIDEROL MT Series bearings are used as shaft support bearings, and center eccentric floating bearings in these and other series Simplex pumps.

SIMPLEX reports unusual success with heavier loads and most satisfactory bearing life through ten years of use of MCGILL bearings. They have helped to produce the strikingly long life for which these pumps have become famous.



### KANE AND ROACH LEVELER SHAFTS ROLL ON GUIDEROL BEARINGS

Kane and Roach depends on 26 matched pairs of GUIDEROL bearings to carry the leveling and flat straightening loads resulting from rolling alloy steels of 80,000 PSI yield. They are used on K & R No. 7 Levelers as roll neck bearings on the 11 power driven main leveler shafts and on the pair of adjustable pinch roll shafts that guide entry of alloy steel bars up to 1" thick by 8" wide.

Shown are the matched GUIDEROL bearings in their roll neck mountings. Driven through universal joints at 38 to 114 RPM, the power rollers, supported at each end by pressure lubricated GUIDEROL bearings, provide production speeds of 70 to 210 feet per minute.

Kane and Roach uses GUIDEROL bearings in many applications with complete assurance of extra capacity and dependable performance with minimum maintenance.

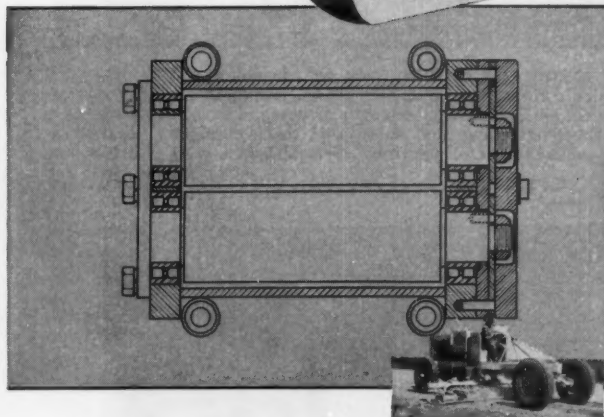
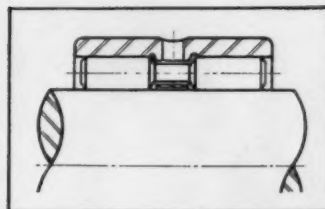


WRITE TODAY FOR FREE MCGILL BEARING CATALOG No. 52-A for complete data on MCGILL GUIDEROL, CAMROL, MULTIROL and CAGEROL BEARINGS.

# capacity in smaller radial space



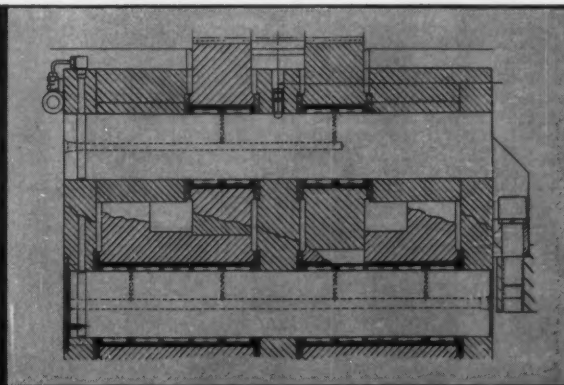
**GUIDEROL BEARING**  
Cutaway to show center guided roller principle



## GUIDEROL BEARINGS WITHSTAND VIBRATION IN LIMA ROADPACKER APPLICATION

GUIDEROL bearings support the off-balance rotors which produce vertical vibration in the six vibrator assemblies of each LIMA ROADPACKER machine. The drawing shows the position of 4 rotor support bearings. A gear motor drives the rotors which are one-half filled with lead to produce vibration for road compacting.

The user states that GUIDEROL bearings were selected because of high capacity in limited diameter and their ability to withstand extensive off-balance vibration. Possible end floating of the separable bearing fits the design very nicely. Performance is considered most satisfactory as the bearings easily resist the eccentric loading.



## GIDDINGS & LEWIS SKIN MILLING MACHINE APPLICATION REQUIRES GUIDEROL RIGIDITY — MINIMUM DEFLECTION

GUIDEROL BEARINGS, IN MATCHED SETS are used to mount the reduction gearing in the table drive gear box of each NUMERCOID tape controlled skin milling machine. The drawing shows a partial section of the table drive. GIDDINGS & LEWIS MACHINE TOOL CO. cites excellent performance of the GUIDEROL bearings. Guided rollers in this bearing have eliminated the problem of having the roller bind on the shaft if slight misalignment is present. The drive assembly mechanism reduces back lash by using a pre-loaded gear arrangement and matched bearings. The bearings are flooded with oil through the center of the shaft. Speeds are 1/30 to 460 RPM.

engineered electrical products



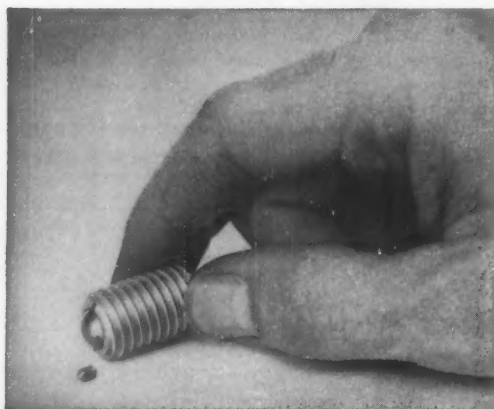
precision needle roller bearings

**MULTIROL-GUIDEROL-CAMROL-CAGEROL**

McGILL MANUFACTURING CO., INC., Bearing Div.,  
200 N. Lafayette St., Valparaiso, Ind.

# Practical Design Tips

No. 4 of a series

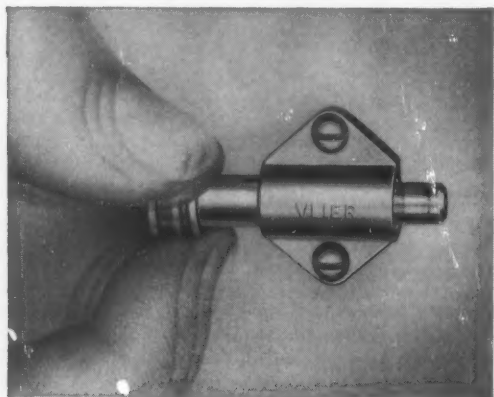


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Hundreds of companies are now saving by using off-the-shelf Vlier products like the ones shown below. These simple, low cost, precision parts save designers time and, in many cases, simplify product design and manufacture. Why not investigate their possibilities today.



**TORQUE-LIMITING WRENCH** for assembling small parts, adjusting set screws, etc., is easily made from a Vlier Torque Handle and a length of hexagon stock. Prevents over-tightening, and subsequent damage to parts. End pressure is adjustable from 15 to 200 lbs.



**NEED A SMALL, LIGHTWEIGHT, SPRING-LOADED LATCH?** One enterprising designer modified a standard Vlier S-88 Spring Stop that did the job perfectly. Entire latch weighs less than 1/3 oz. Body is die-cast aluminum; plunger is heat-treated alloy steel. Various plunger pressures. Available on quantity orders only.



**FREE IDEA BOOKLET.** Illustrations in this 16-page booklet show how others have profited from the use of Vlier products. Illustrates both the usual and unusual applications. May suggest ways you can save. Write for your copy today.

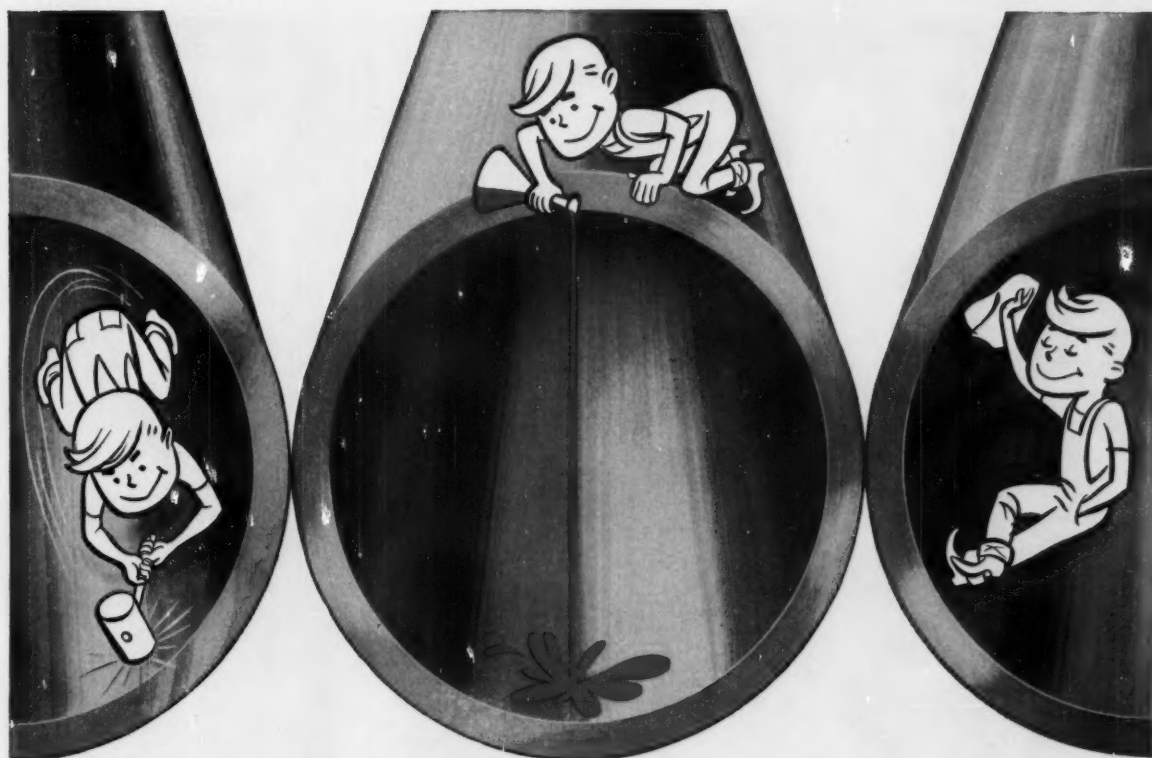
**VLIER**

Engineering Corporation

A subsidiary of Barry Controls, Inc.

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*The smoother surface of*  
**CONTOUR-WELDED\***  
**STAINLESS TUBING**  
*gives it greater resistance to corrosion*

Recent tests prove: (1) Contour-welded tubing is smoother than any other tubing, and (2) this extra smoothness provides greater resistance to corrosion.

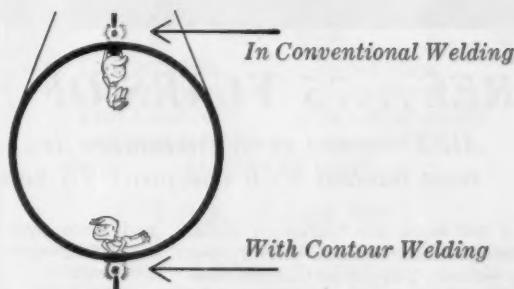
Here's how TRENTWELD® tubing, made by the exclusive Contour-Weld process, compares with other full-finished tubing:

- It's smoother than seamless because it's formed from uniformly rolled strip steel, whereas seamless is extruded from a billet.
- It's smoother than other welded tubing because the Contour-Weld process, patented by Trent, virtually eliminates the weld bead.

Other tests prove this smoother surface provides increased resistance to corrosion — because there are fewer focal points for corrosive attack. Not only that, the smoother surface ensures longer fatigue life and less product incrustation.

But get full details. Our free 48-page "Trentweld Manual" gives complete data on Contour-Welded tubing in sizes from 1/4" to 40" O.D., in stainless and high alloy steels, titanium, zirconium, zircalloy and Hastelloy.† Write: Trent Tube Company, Box 2518, Pittsburgh, Pa.

†Trademark Haynes Stellite Co.



In CONVENTIONAL WELDING of tubes, gravity pulls the molten metal down to form a bead that is difficult to remove by cold working. And cold working may lead to undercuts, focal points for fatigue cracks and corrosive attacks. Cleaning becomes difficult.

\*With CONTOUR-WELDING the tube is welded at the bottom. Gravity still pulls the molten metal down inside the tube, but now the weld area corresponds to the contour of the tube. There's virtually no weld bulge on the inside surface. And even on the O.D., the weld seam more closely conforms to the contour of the tubing.



*stainless and high alloy pipe and tubing*  
**TRENT TUBE COMPANY**

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Photo courtesy Ark-Les-Switch Corp., Watertown, Mass.

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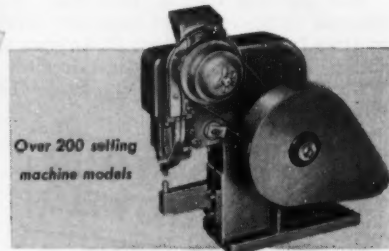
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WEAR RESISTANT  
THOMSON

60 Case

AVOID the HIGH COST  
and difficulty of fabricating  
long, hard & straight  
parts by  
conventional  
methods!

# hardened and ground

*SHAFTS, ROLLS, GUIDE RODS and other long-round parts*  
**ELIMINATE WEAR and REDUCE COST**

60 Case is the result of over 15 years of experimental work and production experience with hardened and ground shafts which are a requirement for BALL BUSHINGS, the Linear Ball Bearing manufactured by Thomson Industries, Inc.

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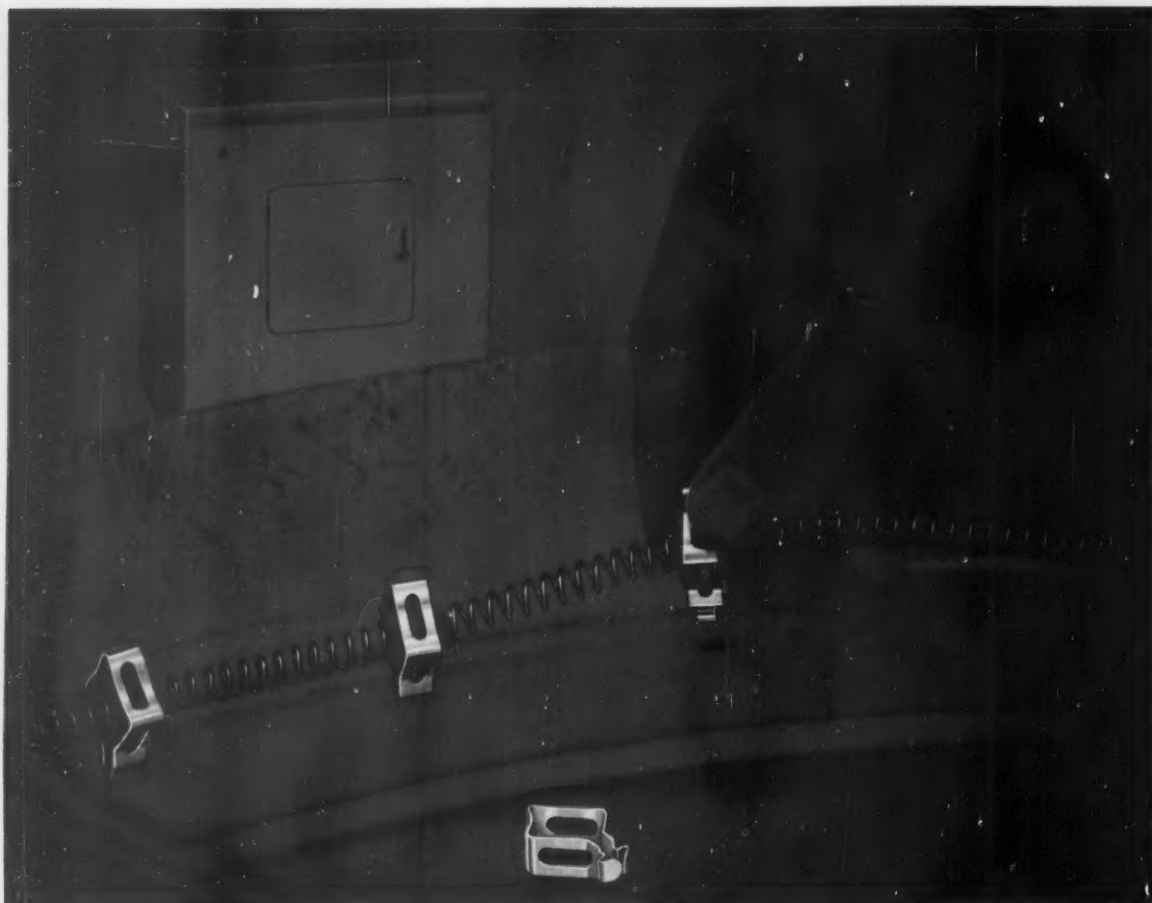
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Circle 467 on Page 19

PARTS HARDENED to 60C...

*increase life...reduce cost!*



Engineered by Tinnerman...

## **SPEED CLIPS®** reduce costs, simplify assembly and servicing on Maytag "Halo of Heat" Dryer

Clothes are dried efficiently in the famous Maytag "Halo of Heat" automatic dryer. And now the quality of the "Halo of Heat" dryer is even better than ever because its unique circular heating element is fastened quickly, securely by 22 special Tinnerman SPEED CLIPS developed by joint efforts of Tinnerman and Maytag designers.

Each one-piece SPEED CLIP eliminates a separate welding operation on the "Halo of Heat" assembly. Various screw-driving operations formerly required on Maytag's assembly line to capture the ceramic insulator and secure the mounting clamp were also eliminated, with equally interesting reductions in cost. Now, the stainless steel, vibration-proof fastener is snapped in place with simple "button-hook" action. No special skills or equipment are required. Assembly and parts costs have been reduced...*substantially!* Serviceability in the field has been improved.

A free Tinnerman Fastening Analysis of your own product can show you where similar assembly and cost-saving advantages are possible. Call your Tinnerman representative—he's listed in the Yellow Pages under "Fasteners". Or write to:

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## Challenge, Interest, Diversity

**I**T has been said that most jobs are ninety per cent drudgery and ten percent thrill. Perhaps, then, a person would do well to choose a career or job according to his attitude toward the "chore" aspect rather than the "glamour" aspect.

Engineer-attitude surveys reported in this issue by Eugene Raudsepp show that challenge, interest, and diversity outrank all other factors in engineering job selection. How many engineers expect these attributes to pervade the whole job?

Among assembly-line workers, according to Harvey Swados in the *Saturday Review*, "the one unifying force . . . was hatred of their work . . . There was a near unanimity of contempt for what they did and a shame at their inability to earn their livings in a better way."

Engineers, fortunately, have not come to such a pass. They are entitled to be a bit snobbish about doing what they term "subprofessional" work. But the prima donna attitude can be pushed too far. After all, the engineer is hired to get the job done. His own edification

should be strictly secondary.

Management is frequently criticized for misuse of engineering talent on routine jobs which aides or technicians could do equally well. But management doesn't always know where the technician's work leaves off and the engineer's begins. Engineers have a responsibility to inform management on just where the line of demarcation lies.

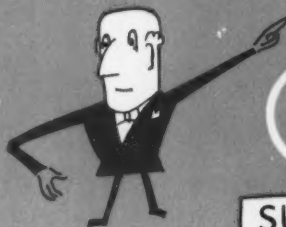
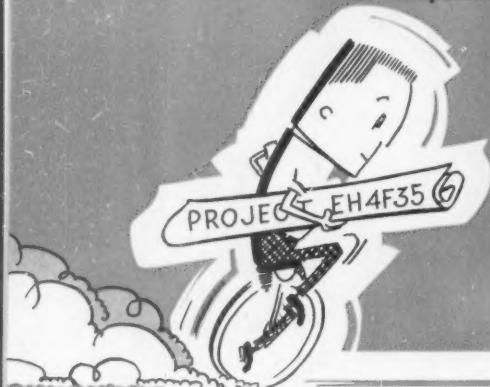
In doing so engineers can more effectively get a hearing for their legitimate gripes if they are reasonable and discriminating. They should attempt to find an honest answer to this question: Do I object to doing this job simply because it is uninteresting to me, or because it really is something that a technician could do equally well at lower cost to the company?

No job can be all glamour and excitement. Many of us have to settle for no more than ten per cent, and learn to be happy with the remaining ninety per cent.

*Colin Carmichael*  
EDITOR

## The Engineer Wants:

1. Programming and scheduling of his work assignments, clearly defined objectives, and planning in detail.
2. A set pattern to follow, but devoid of the tendency to routinize his job.
3. Competent supervisors.



EXCELSIOR

SUMMIT

GOAL



**An engineer can be led to a job,  
but that doesn't mean  
he'll work at it.**

**He works best at jobs he likes,  
in a suitable environment.  
Here are characteristic factors  
of the kinds of jobs  
which engineers seek and keep.**

**T**ODAY, there is more reason than ever to be concerned with the factors that motivate engineers. In hiring, the emphasis has shifted from quantity to quality—hiring the best technical talent available rather than any engineer with minimum qualifications.

Hiring itself has been downgraded in importance by a new accent on engineer utilization—achieving the maximum output from the engineers who are already on the staff. One of the most effective keys to utilization is motivation.

In selecting his job, the engineer chooses the one which seems most likely to provide satisfactions he

is seeking. The dissatisfactions which he may feel on his present job lead him to select a new one where the causes of these dissatisfactions will be absent or minimal.

The factors that motivate job selection and job satisfaction are divided into several broad categories of values: Material, career, status, and human relations. Although the individual factors in each category are discussed separately, the engineer is actually driven or pushed by a combination of needs rather than any single motive.

### ► Material Values

In recent articles,\* it was noted that engineers, on the whole, value concrete, material rewards more than do people in many other professions. This emphasis on tangible benefits is counterbalanced by the engineer's strong sense of responsibility toward his job, and his willingness to work hard for the material values or rewards he expects.

**Income:** In considering salary, the engineer's interest is not solely in the actual or absolute income he will receive. What is psychologically important

\*E. Raudsepp—"The Engineer: Paragon or Paradox?" *MACHINE DESIGN*, "Part 1—His Personality," December 10, 1959, pp. 24 to 28; "Part 2—His Intelligence and Abilities," December 24, 1959, pp. 29 to 31; "Part 3—His Interests," January 7, 1960, pp. 25 to 28.

# Why Engineers Work

**EUGENE RAUDSEPP**

Research Consultant  
Deutsch & Shea  
New York

to him, and what attracts him to a company, is his perception that the salary offered is as much or more than that paid to other engineers on his level.

In addition, the engineer regards salary as an important symbol of status. When he demands a certain rate of pay, he is in effect demanding the recognition to which he feels his qualifications and

professional contributions entitle him.

In five recent Deutsch & Shea surveys listing 24 factors involved in engineer job selection, starting salary ranked first in one, but made a poor showing in the other four. However, taking into consideration all available surveys and studies on job motivation, salary ranked first in six, second in two and third in four surveys, Table 1. Salary

**Table 1—Motivating Factors Which Influence Engineer Job Selections**

Factors (In order of importance)	Number of Surveys in Which Factor Was Ranked:					
	First	Second	Third	Fourth	Fifth	Sixth
Salary	5	2	4	—	2	1
Challenging opportunity	3	3	2	—	1	—
Interesting work	3	2	—	1	—	—
Opportunity for advancement	2	4	1	—	—	—
Location	1	—	6	3	—	—
Type of work	1	1	3	—	2	—
Potential growth of company	1	1	—	3	—	1
Company prestige and reputation	1	—	—	1	1	2
Progressive research and development program	—	1	—	3	1	—
Regular salary increases	—	1	—	—	3	1
Job security	—	—	—	2	—	—
Opportunity for advanced study	—	—	—	—	1	—



## The Engineer Wants:

4. Adequate credit from his company for his ideas and accomplishments.
5. Security in his job—based on his attainments.
6. Favorable regard of top management for his work.
7. Compensation, concrete rewards, and economic advancement.
8. Assurance that his supervisors know how well he is doing.

showed up in these three positions more frequently than any other single factor. The importance of salary is diminished somewhat only when the type of work the engineer is interested in, and other acceptable symbols of professional advancement and recognition are present.

In another recent survey, in which over 3000 engineers participated, *Type of work* was ranked first, followed by *Salary* and *Location*, Table 2.

A number of surveys have shown that salary is currently one of the major causes of engineer discontent. The main reasons for this dissatisfaction were put forth by the Engineers Joint Council in a report on professional standards and employment conditions. The causes (confirmed by other studies) were:

- The feeling that engineer salaries were not commensurate with the fundamental contribution made by the engineer.
- The complaint that the differential between the wages of skilled workers and the salaries of engineers was too small.
- The fact that the salaries of experienced engineers have not been increased in proportion to the rise in starting salaries for engineers.
- Objections to the wide variation of salaries paid to engineers doing comparable work in different organizations.
- Dissatisfaction with merit-review systems and inadequate understanding of salary administration.

**Location:** Within the last few years, location has become one of the more influential factors in engineer job selection. At present, among material attractions, it runs a close second to salary. Although climate seems to be the most important feature of a desirable location, such factors as the availability of educational facilities, professional and cultural opportunities are also part of the picture. And, for the married engineer, a main concern is finding a suitable environment for his family.

**Fringe Benefits:** Inducements such as fringe benefits do not emerge as decisive factors in engineer job selection—they have never ranked higher than seventh. But many benefits, such as company-paid

insurance, stock bonus plans and profit-sharing arrangements, do represent extra money in hand, and thus security against emergencies. The company that does not offer at least some benefits is at a definite disadvantage.

**Security:** It is important to note that "security" involves several separate factors. In terms of the engineer and his job, security includes:

*Personal security*, the knowledge that he will be given a fair chance to keep his present job and, in time, an opportunity to move up into more important ones. The assurance that he is valued as an individual.

*Department security*, the assurance that his department or division enjoys high standing within the company so that its work, and consequently his, will not be stymied by cutbacks.

*Company security*, the assurance that his firm is keeping up with the others in the field and with engineering developments in general. This is often indicated by the company's research and development expenditures, the manufacture of new products, the undertaking of new projects, and the company's financial stability.

*Industry security*, the assurance that the industry or field itself is distinguished for its progress and achievements.

Many maintain that security is one of the least important considerations to the contemporary engineer, even in spite of the recent recession and the changing political climate. Some spokesmen of the engineering profession believe that today's imbalance between technical supply and demand will continue and will make "getting another job" a relatively simple matter. Furthermore, engineers are very much aware of the fact that almost every change in jobs, at the present, is accompanied by an increase in salary. It seems that some engineers, especially young ones, want to capitalize on their mobility and look on a position merely as a stop-gap—a means of accumulating experience to enable them to climb the salary scale more rapidly.

Although, at present, security may not be one of the primary motivational factors in engineer job

selection, it should not be ignored. A sudden downturn in demand, a further change in the political climate, or a sign of another recession could very easily see it assume major proportions.

### ► Career Values

Most studies indicate that the engineer is intensely career-oriented. He is serious-minded, conscientious, and willing to devote an enormous amount of energy to his work. Because he is so dedicated to his career, he pays particularly close attention to the job factors that contribute to the realization of his aspirations. Some of his major career values are: Stimulating work, opportunity for advancement, opportunity for greater responsibility, opportunity for training and education, and proper utilization.

**Stimulating Work:** The unprecedented strides made by technology in the last few years have created a variety of engineering work which seemed inconceivable a generation ago. In fact, much of our present demand for engineers comes from the so-called "glamour" fields—nucleonics, electronics, and missiles—which were merely embryonic or completely nonexistent a few years ago. This superabundance of stimulating opportunities has made the nature of the work he will be doing an important motivating factor.

Several studies illustrate the extent to which the

factors of challenge, interest, and diversity influence engineer job selection. On most of Deutsch & Shea's job acceptance surveys, "opportunity for interesting work" was rated the single most important consideration, followed closely by similarly work-oriented factors such as "opportunity for diversified work," and "challenging opportunity."

**Opportunity for Advancement:** Like salary considerations, development and advancement opportunities have both a practical value and a symbolic or status value in that they reinforce the engineer's opinions of his worth and ability.

One survey conducted by the Opinion Research Corp. found that "opportunity for advancement" and a "chance to do creative work" were considered the two most vital job factors by 265 engineers. In another study, also by Opinion Research Corp., 67 per cent of 622 engineers and scientists felt that getting ahead is more a matter of politics than of knowledge. They complain that to gain influence in the company, they must leave the laboratories for the executive suite.

**Opportunity for Greater Responsibility:** The typical engineer, both as a professional and an individual, is a markedly independent person. Because he has a self-directing attitude toward his work, he is happiest when given relatively little supervision.

The more experienced engineer, especially, wants

**Table 2—Motivating Factors by Fields of Engineering**

Factors (In order of importance)	Total	Re- search	Develop- ment	Design	Oper- ation	Pro- duction	Admin. Mgt.	Sales	Other	No Answer
	(per cent)									
Type of work, interesting, diversified .....	45.0	52.1	45.7	45.0	42.8	41.8	41.1	43.9	46.5	41.7
Salary .....	33.9	31.3	39.5	37.8	25.2	32.9	34.0	31.1	23.2	16.7
Location, good place to live, family .....	31.2	33.6	37.3	30.2	27.7	33.6	27.1	13.5	24.5	50.0
Opportunity for advancement .....	29.8	22.6	25.6	27.7	27.0	32.2	39.5	36.5	22.6	8.3
Challenge, more responsibility, chance to use creative ability .....	16.9	18.5	15.5	17.0	20.1	19.2	18.7	22.3	25.8	25.0
Reputation, prestige of company .....	13.7	9.1	13.5	13.6	13.8	15.8	14.9	12.8	11.6	8.3
Working conditions, personnel policies .....	11.7	14.0	12.1	11.9	13.2	10.3	9.6	14.9	7.7	8.3
Growing organization, growing field .....	6.9	6.4	9.3	5.8	5.7	7.5	8.4	6.1	5.8	—
Security, retirement plan, benefits .....	6.8	7.2	7.3	6.3	12.6	3.4	6.9	5.4	3.2	8.3
Opportunity to learn, broaden experience, training programs .....	6.6	11.3	7.9	6.0	5.0	7.5	5.9	2.7	6.4	—
Small company .....	4.1	2.6	3.3	4.3	4.4	6.2	4.3	4.1	3.9	8.3
Job was available .....	3.4	2.6	2.6	4.9	3.1	4.8	2.8	3.4	3.2	—
Progressive research and development program .....	2.8	8.7	3.5	3.6	3.8	2.1	2.6	3.4	1.9	—
Own business, partnership, independence .....	2.7	2.6	2.0	4.0	4.4	2.1	3.5	6.8	3.9	—
Type of product .....	2.5	0.8	2.6	2.7	1.3	0.7	1.6	4.1	2.6	8.3
Previous association with company .....	1.8	2.6	1.5	1.6	1.9	3.4	1.0	1.4	1.9	8.3
Public service, humanistic reasons .....	1.3	1.5	0.7	0.9	2.5	2.1	1.2	2.7	1.9	8.3
Opportunity to travel .....	1.3	—	0.4	1.5	1.9	—	1.0	4.1	1.9	—
Regular salary increases .....	0.4	0.8	0.4	0.7	—	0.7	0.6	—	1.9	—
All others .....	1.9	1.9	2.2	1.3	1.3	0.7	2.8	2.0	1.9	—
No answer .....	2.7	1.5	1.5	2.7	4.4	3.4	2.4	0.7	2.6	8.3



## The Engineer Wants:

9. Opportunity to influence work on technical projects.
10. Follow-through, performed by himself, on the job he has started.
11. Participation in decisions which affect him.
12. Opportunity to see his ideas put to use.
13. Freedom to maintain an independent, self-directing attitude on how to tackle any particular problem.

to check personally the facts and details in his assignments, and then devise his own methods and create his own solutions with a minimum of restraint on his initiative. Although he realizes that he will often have to work as part of a team, he does demand that his company have confidence in his ability to assume responsibility and respect for his desire for independence.

Dr. Donald C. Pelz, of the Institute for Social Research of the University of Michigan, considers responsibility as one of the more important "intrinsic motivations" of the engineer. He says:

One (source of intrinsic motivation) is the degree to which the company has been successful in giving a large measure of *individual responsibility* to the technical man. One person referred to this process by a term which I thought very appropriate; he called it "controlled freedom." A general problem area is sketched out for him, he is shown what mountain to climb, and then it is up to him to get to the top. However, by no means is he ignored. He is encouraged to sketch out a program which is discussed, and he makes regular progress reports. . . . Secondly, the technical man is encouraged to maintain close direct contact with other people who have an interest in what he is doing, and to whom his work is important. . . . The feeling that other people are interested in your work is an excellent way of making it interesting to yourself.

**Opportunity for Training and Education:** The engineer, dedicated as he is to his work and career, fully realizes that the more he knows, the more he is worth to his company, and consequently the greater will be his chances of professional and financial advancement. This career-consciousness, coupled with an intense, technically oriented curiosity, is responsible for his concern, especially if he is young and inexperienced, with such factors as special in-plant training, on-the-job coaching, and opportunities to continue formal education.

There seems to be a definite correlation between the desire for advanced education and the engineer's age, amount of experience, and marital status. According to most surveys, single men are far more concerned with the availability of educational facilities than those who are married, and engineers

with two or more dependents tend to be less interested in graduate study than those with one or no dependents. Opportunity for advanced education rates very high among engineers during their first four years in the profession. After about six years of experience, the importance of educational opportunities falls off sharply.

**Proper Utilization:** An engineer's expectations of satisfaction with his work are high, stimulated by his own interest, by the educational process through which he passes and, in the case of the newer engineer, by the assurances of employers that he is going to do interesting work.

The young engineer is frequently disillusioned when he finds himself doing routine work, and the older engineer often finds himself enmeshed in a specialization which hinders his chances for advancement and development. The complexity of many modern products means that the engineer may be doing the engineering equivalent of bolt-tightening on a production line. Often, too, he feels held down by his supervisor or by management. A frequent complaint is that supervisors "bury good men" to keep their services.

Much of the engineer's professional standing is tied up in the work he is doing. If it is interesting, new, worthwhile work, he can write papers about it and gain recognition among his fellows. This is in addition to the intrinsic satisfaction he finds in challenging work. Accomplishments which are worthwhile fortify his own feelings of worth and value, and give him a kind of justification in his interests and his choice of the engineering career.

Routine, uninteresting, and subprofessional work, on the other hand, induce negative feelings not only about the work, but about the company which provides it. Under these conditions, minor irritations become major causes for complaint and, eventually, causes of high turnover and/or unionization. In a study just issued by Opinion Research Corp., 72 per cent of 622 engineers and scientists felt that management misuses their talents.

Engineers are, in general, individualistic. The more creative and the more productive engineers

are literally men in love with their work, who prefer working at their chosen profession to the exclusion of almost every other consideration—even recreation. When this powerful drive is thwarted or side-tracked by improper utilization, job dissatisfaction becomes apparent in short order.

### ► Status Values

More than people in other professions, the engineer is preoccupied with his professional status. There is much doubt among engineers regarding their professional status in companies and many engineers doubt, too, whether society regards them as professionals.

Factors, such as salary, advancement, and education, have status attraction in addition to their other values. Those factors which more directly or obviously satisfy the engineer's need for status are: Professional recognition, the reputation and prestige of the company, professionally oriented personnel practices and policies, favorable working conditions, and adequate facilities.

**Professional Recognition:** The term "recognition" has a rather broad meaning and involves many separate factors which in themselves play important roles in job selection. For example, adequate facilities and good working conditions are often regarded as indications of management's recognition of its engineers' worth. Thus, facilities become symbols of status, and their presence in a company may be important to the engineer's well-being.

Another status-augmenting factor is the provision of adequate technical assistance. The engineer interprets occasional assignments to routine, low-grade chores as a refusal by management to accord him the recognition which he thinks he deserves. Companies that have been able to provide their engineers with technical assistance report an encouraging improvement in morale and turnover.

During an attitude survey, one engineer explained his reasons for accepting a new job in this way:

My friends tell me that top management in that company (where he was accepting a new job) really re-

spects engineers and that the engineering department has as much prestige as any other part of the business. I know this is true because they have all the computer equipment they need, whereas we have only some antiquated stuff. They have a good engineering library and their men are encouraged and actually take part in technical sessions of all kinds. Furthermore, these men are doing the kind of work that gives a man something to talk and write about professionally and that's not the kind of work we get around here.

Outside recognition is as important to the engineer as that which he receives within his firm. It is a wise company that makes it a practice to encourage prestige and recognition activities such as membership and participation in professional societies, publication of the results of nonconfidential work, lecturing, and teaching.

Recognition is not a matter of individual concessions as the engineer sees it, but rather a complete climate controlled directly by management attitudes. Where a climate of recognition does not prevail, the engineer tends to grasp at small things as symbols of the over-all recognition he lacks, and to gripe about environment or restrictive regulations. He will often concentrate his drive for recognition to the area of salary alone. Recognition may be considered as a factor which underlies almost all other areas of engineer job satisfaction.

Recognition is closely related to the engineer's need for status. Recent studies have shown that increasing numbers of engineers in industry set their goals early on the administrative or management career and on sales. To explore the reason why so many technical men apparently regard the administrative career more rewarding, and how this perception has affected their own career choice, Deutsch & Shea asked some 3000 engineers to indicate their reactions to three questions:

1. From your experience, which offers the greatest opportunities for an engineer to advance?
2. Which of these directions have you chosen for your own career?
3. If all other considerations were equal (salary, opportunity, etc.), which type of work would you choose?

Nearly 80 per cent of the respondents felt that

**Table 3—Engineers' Opinions of Other Fields**

Areas of Work	Offers Greatest Advancement	Direction of Own Career (per cent)	Career Choice If Opportunities Equal
Administration (Management)	61.5	45.9	35.0
Sales	17.8	8.5	7.3
Technical specialization	15.4	43.4	53.5
Technical administration	0.9	0.5	0.8
Consulting	0.3	0.5	1.1
Teaching	0.1	0.7	1.4
Others and not specified	4.0	0.5	0.9



## The Engineer Wants:

14. The right work assignment.
15. Variety of professional work.
16. Work that is challenging and stimulating.
17. Planned programs of opportunities for self-development and advancement.
18. Information which explains how his work fits into the entire project or product.

more opportunity for advancement lies outside technical specialization. Other results are shown in Table 3. Relatively few engineers direct their careers toward areas of greatest advancement.

That engineers' actual interests lie in technical specialization is indicated by their clear-cut preferences when all other considerations in the three areas are held equal. Teaching, consulting, and technical administration are not considered attractive areas.

In what specific ways are the opportunities and rewards considered to be greater in the management hierarchy? It appears that the following factors are involved:

1. The engineer feels that the salaries paid to management are substantially greater than the salaries paid to technical men. Furthermore, while the engineer is aware of salary ceilings in the technical area, he does not perceive any ceilings where management is concerned. Management to him is favored by more tangible and intangible opportunities.
2. He feels that ability and performance in management positions is valued more than outstanding technical talent and skill.
3. He feels that the levels of authority and responsibility in the management area are better defined.
4. He imputes the image of success and status to men who progress along the management hierarchy. The engineer, he feels, has not achieved real professional status in industry.

These are powerful inducements and their absence in the technical area make many engineers dissatisfied with their progress.

Rather than make the values of the technical area equally attractive, management in many companies continues to reinforce the attractiveness of the administrative image. Outstanding technical people are still promoted into management, not because they are believed to have the requisite administrative skills, but because this is considered the only suitable reward. In many companies, research and development departments are considered the best training grounds for future administrators.

This trend, if it continues, does not only indi-

cate what might become a serious depletion of valuable technical manpower, it may also cut into the effectiveness and maximal utilization of the people now in technical jobs.

As the responses to this study indicated, the trend to regard management as the really attractive alternative is not irreversible. If technical proficiency were effectively equated with the symbols of success, general morale, efficiency, and utilization in the technical areas would go up considerably.

It would take quite a bit of doing. This becomes evident in a report just published by Opinion Research Corp. of Princeton. The study found that 65 per cent of the 622 engineers and scientists surveyed felt that management was considered among "the most highly respected in the company," while only 8 per cent said that they themselves would fit that description.

As one respondent put it: "The company only pays lip service to the idea and policy that a scientist can advance in stature, pay, recognition, and prestige without getting into administrative work. Without getting out of actual research, there appears to be nowhere to go after about 10 years of service."

The study also found that the same thing holds for the community. When asked to name those "well thought of" in the community, 56 per cent of the engineers and scientists named management, and only 9 per cent classified themselves as such.

**Personnel Policies and Practices:** Of all company policies, time regulations and punching the time clock are by far the most serious offenses to the engineer's sense of self-worth. For one thing, the engineer does not feel that time is an adequate measure of his professional contribution. He wants a company that will permit him to use his discretion and trust him not to abuse his privileges.

A recent survey found that secretarial assistance on call, company-supported technical library, and responsibility for own time without punching time clocks are the most important positive features of company personnel policies to the engineer. Also high on the list were private or semiprivate work-

ing areas and a listing in the company or plant telephone directory.

**Company Reputation and Prestige:** Organizations distinguished for their stability, professional growth and advancement potential, and sound personnel policies have the easiest time attracting and holding highly qualified engineers.

The engineer may not actually be aware of the way in which company reputation and prestige influence his job decision. Throughout his life, especially during the course of his professional schooling and working experience, he develops a mental picture or "company image" of several firms. By the time he is ready to look for a job, he has, often unconsciously, selected certain companies.

Company reputation and prestige might be divided into two parts: Reputation and prestige as a producer, and that as an employer. The main findings which emerged from a recent Deutsch & Shea motivation study on corporate image appear in Table 4. That study covered 12 companies.

**Working Conditions and Facilities:** Although good working conditions and the availability of adequate facilities are not, according to most surveys, the major factors in job selection and satisfaction, the company that provides its engineers with modern laboratories, up-to-date equipment and ample work-

ing space undoubtedly has the advantage over the firm that crowds its engineers into tiny work areas and provides them with obsolescent equipment.

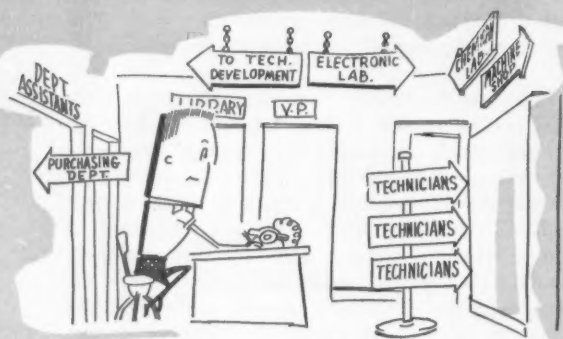
**Technical Assistance:** Numerous articles in technical magazines and professional journals have attributed much of today's engineering shortage—and even professional dissatisfaction in general—to the fact that the engineer is forced to devote a great deal of time and energy to the performance of routine, low-grade chores. He feels that this work should be handled by technical aides in much the same way that therapists, nurses, and laboratory assistants lighten and extend the work of doctors and dentists.

It should be pointed out, however, that there are some engineers to whom the availability of supporting personnel has apparently a negligible effect on job selection. On most of Deutsch & Shea's job acceptance surveys, "favorable ratio of technicians to engineers" appeared at the bottom of the list of motivating factors.

Regardless of whether or not adequate technical assistance is one of the really vital factors in job selection, frequent assignment to nontechnical or subprofessional work contributes nothing to the engineer's status and work interest. It seems safe to say that the engineer prefers a company where routine chores are relegated to aides, leaving him more

**Table 4—Engineer's-Eye View of Employer-Companies**

1. Engineers do have preconceptions about companies even though they have had no personal contact with the companies, and these preconceptions affect their feelings about the companies as potential employers.
2. Their image of the various companies exists independently of the factors of salaries and location, and there is surprising consistency among the various fields of engineering specialization studied in regard to the images held of various firms.
3. Engineers prefer working for firms about which they have a substantial amount of information.
4. The information sources which appear to be most important in influencing engineer opinions about engineering firms are those which involve personal contact.
5. There is consistency in the way engineers respond to different aspects of a company. An engineering firm, in the image it presents, is likely to be no stronger than its weakest public front.
6. The stronger, the more personalized a firm's image is, the more readily is it accepted as a potential employer—if the image is predominantly a favorable one.
7. Large companies tend to be regarded with considerable ambivalence. While they are viewed generally with more favorable than unfavorable attitudes, there is some concern about the large firm stifling individual creativity and a rather reluctant respect for its stability, prestige, and competence.
8. The weakest component in company image is the area of employment practices, which reflects on the general professional morale problem.
9. Engineers are a clannish and self-protective group. While they might be highly critical of a company's management, products, personnel practices, they do not, as a rule, hold the engineers working there in low esteem.
10. One of the most significant aspects of a company so far as company image is concerned, is its development and growth potential.
11. The language and adjectives used in discussing a company show variability in intensity as well as in positive, neutral, or negative feeling tone and in other dimensions. Some firms, for example, tend to be personalized and are described as being "creative" or "imaginative" or "forward-looking." Others are viewed more blandly as "successful" or "important" or "well-known."



## The Engineer Wants:

19. Adequate facilities to get his work done.
20. A well-organized supporting staff and adequate technical assistance.
21. Employment in a company that is known for its excellent products and reputable professional staff.
22. Association with a company which clearly defines authority and responsibility.

time to devote to the important and stimulating work for which he has been specially trained.

### Human Relations Values

Two areas of human relations of greatest concern to the engineer are supervision and engineer-management communications.

**Supervision:** The favorable environment that is vital to the engineer's efficiency, productivity, and general satisfaction is created to a large extent by the quality of the supervision he receives. For one thing, the engineer has more contact with his supervisor than with any other manager in the company. For another, the supervisor plays perhaps the most important role in his personal and professional advancement.

Engineers prefer and work most effectively under a task-oriented supervisor rather than a supervisor who follows an authoritarian or even laissez-faire pattern. The model supervisor should be one who is capable of delegating work efficiently and equitably. His supervision should never be so close and inflexible as to thwart the engineer and stifle his imagination and initiative.\*

**Engineer-Management Communication:** Dr. Herbert A. Shepard of Standard Oil Co. has called engineers "marginal men" because they work in an area that is not quite science and not quite business, but is associated with both. In some ways engineers are intermediaries—even translators or interpreters—between business and scientific points of view.

One study has suggested that there is an actual language barrier between the executive-supervisory group and the professional-technical group. Executives are seen as yes-and-no men, men of decision who tend to see in terms of black and white. Technically trained men are prone to see all shades of gray.

\*E. Raudsepp—"The Ideal Creative Supervisor," *MACHINE DESIGN*, Part 1, September 18, 1958, pp. 26 to 28; Part 2, October 2, 1958, pp. 28 to 32; Part 3, October 16, 1958, pp. 30 to 34.

Another authority has suggested that the lack of understanding between the professional employee and management lies in the fact that the engineer is job-oriented. He is primarily concerned with competent performance in his specialty, while executives tend to take pride in integrative skills and the ability to operate in many fields. Management has accused engineers of chronically "overelaborating the obvious," while the engineer often feels that management is "disorganized" and doesn't really know what it is doing.

When even the mechanics of management-engineer communication have broken down—or have never been established—a situation arises which can easily lend to discontent in engineers and trouble for management. That such situations are fairly common is indicated by a number of studies and surveys.

A major electronics company, for instance, surveyed its own engineering staff, and found complaints about many facets of communication:

60 per cent said they were not given as much information about the company's operations and the activities of other functions as they should have in order to do their work properly.

39 per cent said the supervisors did not keep the engineers informed about what was going on.

31 per cent said they usually or frequently have to find things out indirectly which they should have been told about through proper channels.

30 per cent said the company was too close-mouthed about matters of information about which they, as engineers, should know.

An NSPE study emphasized the difference in executive and engineer outlook in the area of communications: 85 per cent of the executives surveyed felt that the company's engineers were kept currently informed of their personal progress; only 50 per cent of the engineers surveyed were of the same opinion.

An Opinion Research Corp. study noted that one of the most frequent complaints—made by 61 per cent of the engineers surveyed—was that engineers are not kept properly informed of company policy and operations outside their own work.

The Engineers Joint Council noted that "inadequate communication between top management and nonsupervisory engineers" was one of the factors contributing to serious engineer dissatisfaction.

A major department in a company, noted for its advanced management policies, surveyed its engineers' attitudes and found that only a third felt they were not handicapped in some degree by lack of information about the work of other sections of the department or by lack of knowledge of company plans which affect their work. Only 16 per cent said they got enough information about what was going on in the whole department.

Of 265 engineers from large companies taking part in a depth interview study, more than 30 per cent indicated that they were not kept fully informed on company policy, and were not asked advice in matters related to engineers.

An uninformed engineer finds himself frustrated because he has few channels by which he can get his own ideas upward; and he is not consulted by management to determine what his thinking is even on matters directly related to him. ("There is inadequate communication up and down the line. Management sometimes makes decisions directly contrary to our recommendations, and you are never even told why," said a respondent to an Opinion Research Corp. study.) He also has little upward communication or none, so far as his personal grievances are concerned, though the blue-collar workers who are supposedly below him in status have an efficient mechanism for this purpose.

His lateral channels of communication are equally poor, and he frequently has trouble learning what is going on in immediately adjacent sections or departments, though this may have a vital impact on his work. Nor does he have a better picture of what may be going on in other parts of the company. The only channel of communication which operates with any efficiency is the downward sifting of communication from management. Even this he finds difficult to interpret and insufficient for his needs. His immediate supervisor seems indifferent too.

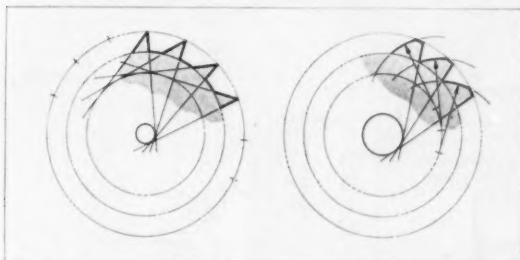
The engineer tends to interpret this lack of communication as another example of his lack of status and the little importance which management places on his activities.

The engineer's preoccupation with the technical aspects of his work insulates him to some degree from the verbal world in which he also lives. But not so much so that communication has not become a major motivational factor in job satisfaction. So vital is it, indeed, that the Engineers Joint Council cites "lack of appropriate means for resolving individual problems" as a condition which has "fostered collective bargaining among engineers." In addition, management loses both the contribution which the engineer might make, were more channels open to him, and the more effective use he might make of his work if he were fully conversant with the company-wide picture of needs, policies, and activities.

## Tips and Techniques

### Tooth Layout

To lay out a ratchet or toothed wheel, draw the OD and the root diameter circle, and divide for the number of teeth. Draw one tooth form and extend leading and trailing edges toward the center. Now draw tangent circles to these edges. Draw the remaining teeth tangent to these circles, completing the



wheel. If one edge of the teeth is a circular arc, the centers of all such arcs will lie on a construction circle as shown in above drawing.—TOMMY N. TYLER, Littleton, Colorado.

### LeRoy Lettering Variations

Variations of the standard LeRoy alphabet letters are easily made by moving the guide to the right or the left. A standard LeRoy number 200 template

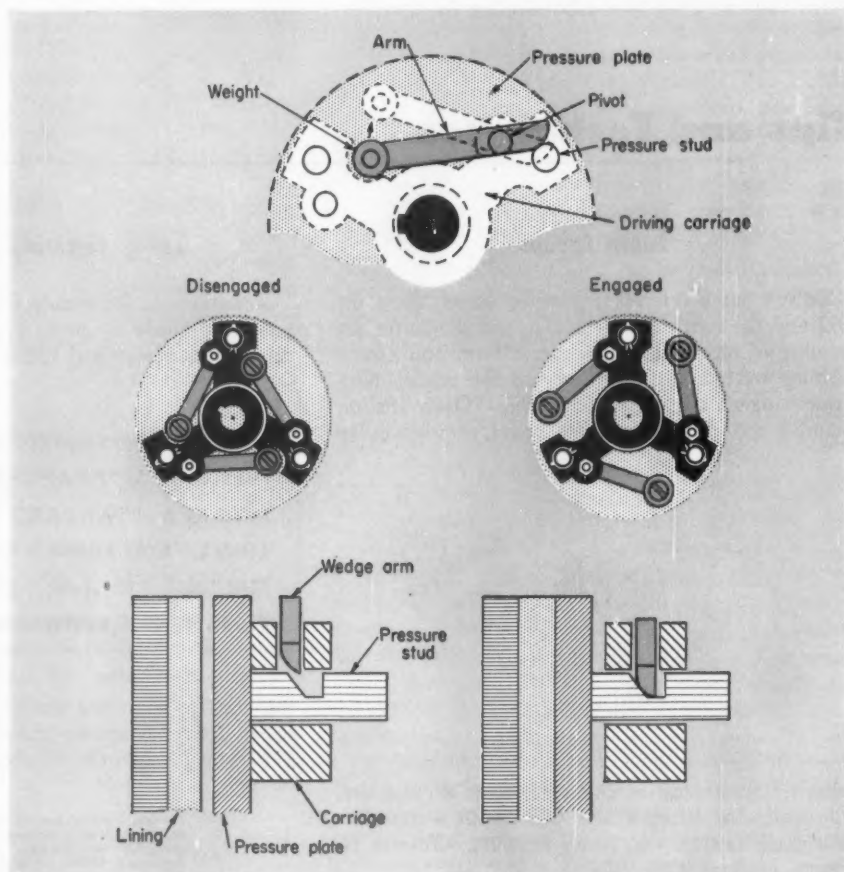
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THIS IS A STANDARD 200 TEMPLATE  
THIS IS A STANDARD 200 TEMP.

was used to make the variations (shown in reduced size). Many others are possible.—F. H. HADFIELD, Stromberg-Carlson Co., Rochester, N. Y.

*Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.*

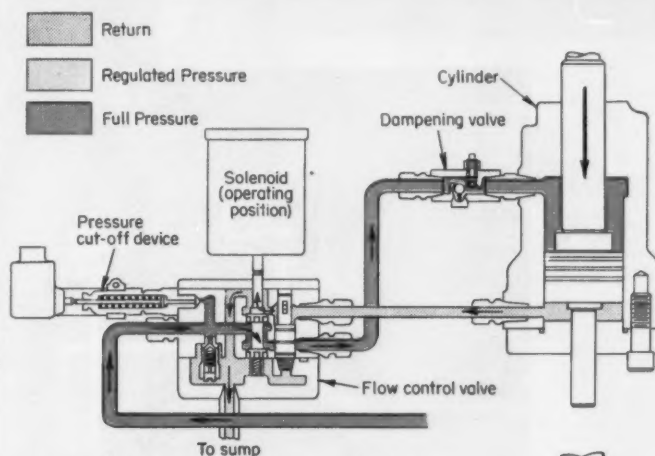
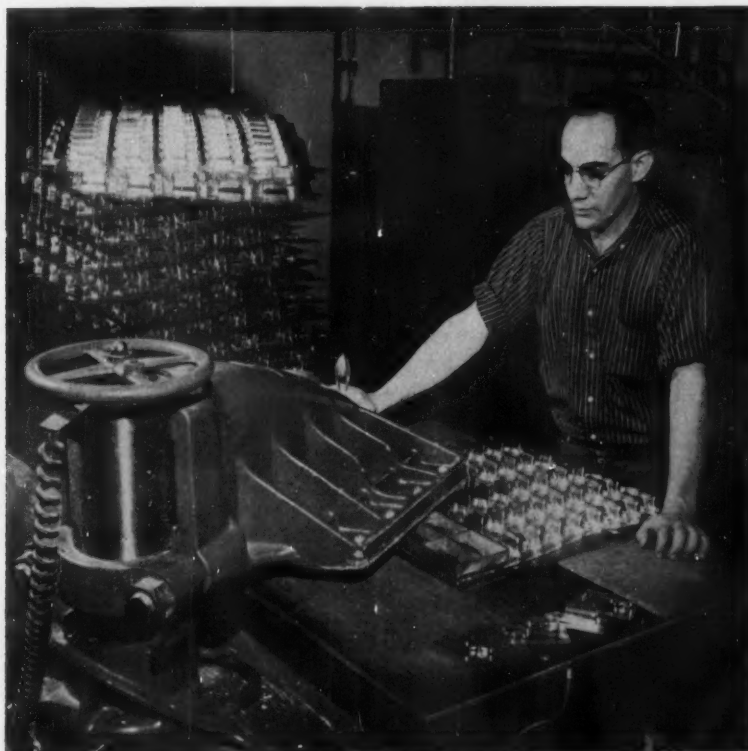
## scanning the field for *ideas*

**Flying wedges** produce positive engagement between clutch pressure-plate and lining. As the assembly rotates, weights attached to one end of pivoted wedge arm are thrown outward by centrifugal force. As the arm pivots, the wedge end of the arm rides down the groove face in the pressure studs, forcing the pressure plate against the lining. Wedge principle employed in a clutch developed by United Specialties Div., Industrial Enterprises Inc., Chicago.

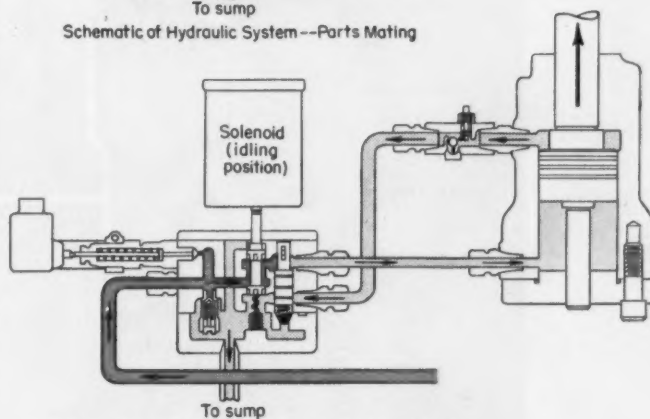


### Electrically conductive impact surface

controls hydraulic system to minimize dynamic loading between shock members. In a cutter assembly, the ram and platen are both part of an electrical circuit. During the cutting operation, oil pressure is directed to the upper part of the cylinder to drive the ram. When the cutting member, driven by the ram makes contact with the platen, an electrical circuit is completed and a hydraulic valve-spool solenoid is disconnected causing the oil pressure to flow from the upper cylinder chamber through a ball check into the dampening valve. The fluid is metered out by the adjusting screw to reduce impact and is exhausted into the reservoir. Conductive-surface employed in Hytronic cutting machine developed by United Shoe Machinery Corp., Boston



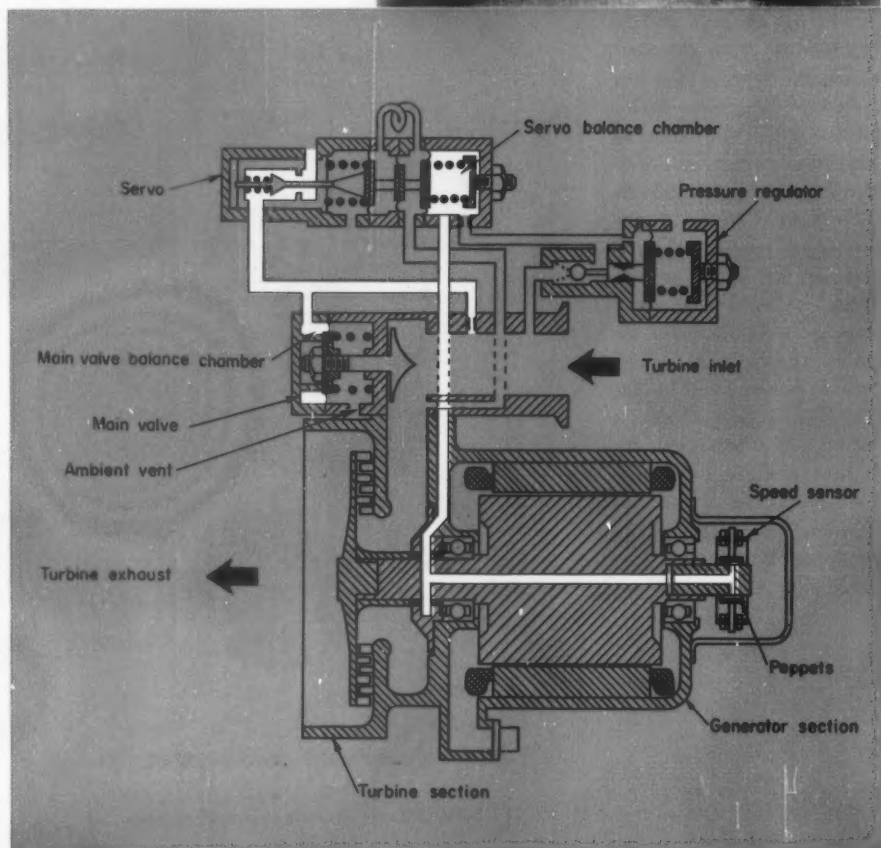
Schematic of Hydraulic System --Parts Mating

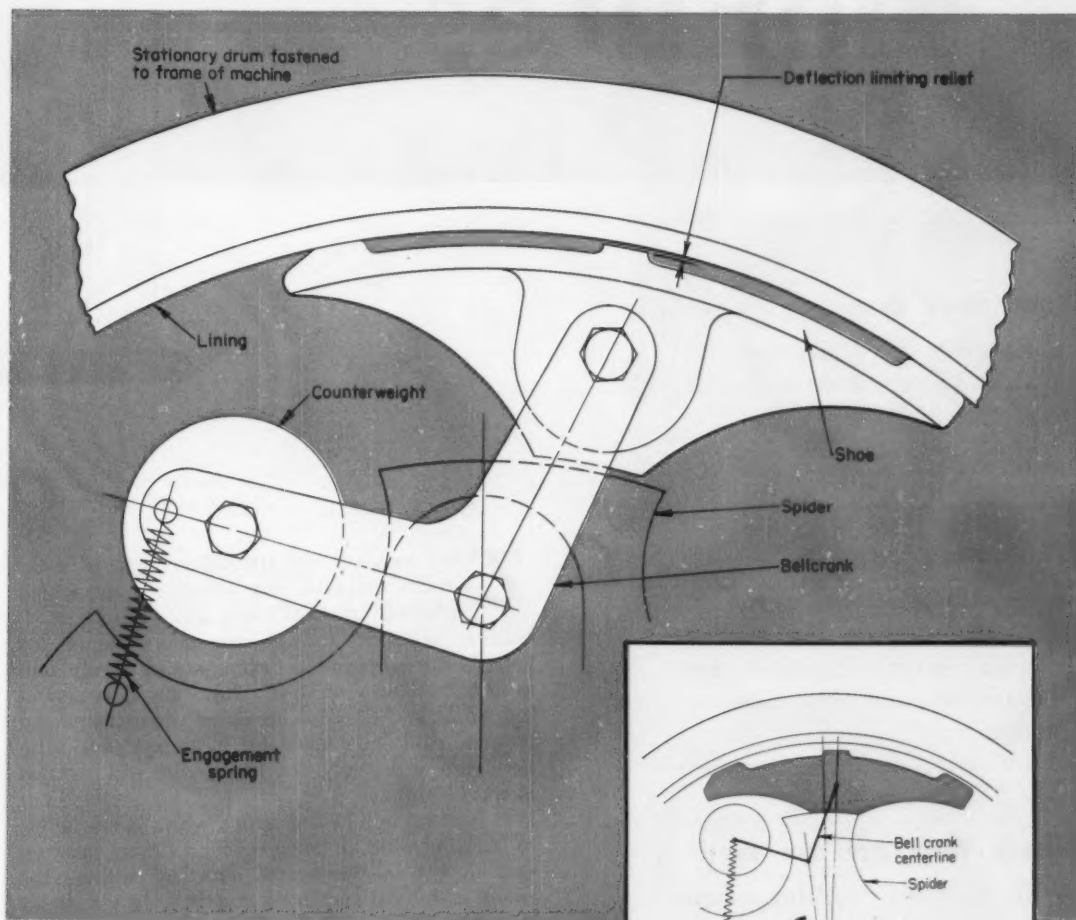


Schematic of Hydraulic System --Parts Separated

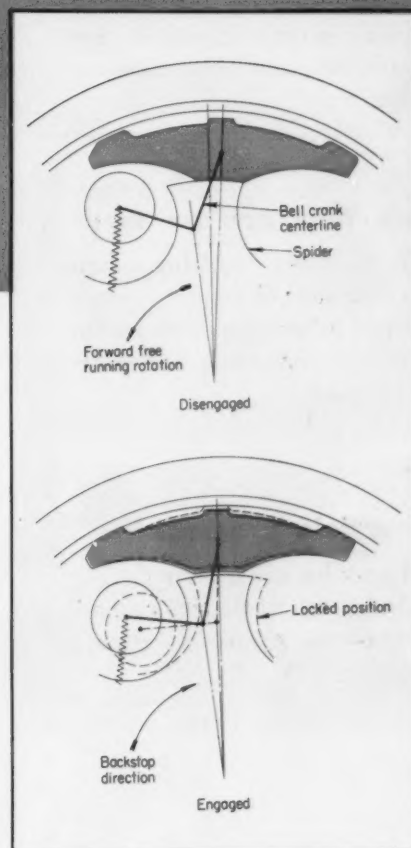
**Centrifugal air bleed** provides governing action for control of turbine speed. As the speed of the turbine reaches a predetermined value, the centrifugal force exerted on the free section of a box-type spring poppet retainer attached to the turbine shaft lifts a pair of poppets from their seats. As air is bled through the rotating poppet assembly, the pressure in the balance chamber of a servo valve is decreased permitting the servo-valve piston to close. This action produces a higher pressure signal which is fed to the balance chamber of the main poppet-valve. Modulation of the main valve regulates the amount of input and, hence, the speed of the turbine. Air-

bleed principle employed in the Flexure Speed Sensor developed by AiResearch Mfg. Div. of Arizona, Phoenix, Arizona.





**Deflecting brake shoes** absorb high shock loads set up by fluctuating torques in rotating equipment. In a centrifugal backstop coupling, the shoes are fastened to a driving spider member by bellcrank links. Counterweights on the opposite end of the links counteract the force of an engaging spring, and the centrifugal force of the rotating shoes. While rotating in the forward direction, the shoes are not engaged with the stationary drum because of the forces acting on the link. But, when a reverse torque is applied, the speed is reduced and the spring force overcomes the centrifugal force to engage the shoe. The center contact-surface of the shoe is relieved, permitting it to bend as a beam under high load. This provides stress compensation for a certain degree of angular motion to prevent over-stressing of the components. Under steady reverse-torque loads, only the outside surfaces are engaged. However, under momentary peak torque loads, the center section deflects to engage drum. Reported by James E. Ettore, shoe design used in Twiflex backstop developed by Hilliard Corp., Elmira, N. Y.



# Flexures

## What they are

Elements that utilize their elasticity to permit controlled deflection.

## What they can do

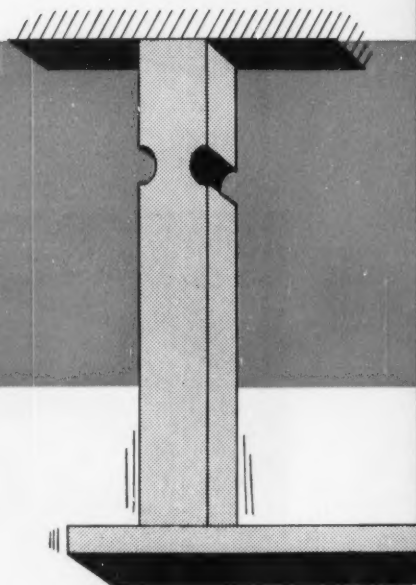
Provide freedom of movement in one or more directions, rigidity in other directions, zero backlash, and frictionless action.

## Where they can be used

In situations requiring a limited amount of deflection—universal joints, vibrators, control linkages, balances, and microactuators.

## This article presents

- A roundup of flexure types.
- Design equations for one basic form—the transverse circular flexure.



**Z**ERO backlash and frictionless action<sup>1,2</sup> make flexures adaptable to a variety of applications, including universal joints, control linkages, vibrators, balances, and microactuators. Since the parts which surround a flexure are elastically connected, problems of wear, lubrication, structural soundness, and vibration are either eliminated or can be more easily accommodated in an analytical solution. Also, a properly designed flexure will function almost indefinitely.

In contrast to a helical spring, which is susceptible to buckling when in compression, a flexure must retain rigidity in the desired directions without the use of additional stabilizing members. In the simple transverse flexure, Fig. 1, the only permissible motion is about the X-X axis. In Fig. 2, the spool-shaped portion is stiff axially but very flexible in all three planes of rotation.

The motion that can be tolerated becomes critical, of course, when sharply defined pivot rotation is desired.

For other uses, some clever arrangements have been devised to reduce the stress concentration by the use of longer flexible connectors to distribute the deflection, Fig. 3. Sometimes preloading or counterbalancing is necessary to prevent buckling. Although such measures may be troublesome, they often can be arranged to compensate for the elastic restoring forces.

With friction and play already negligible, the self-compensated flexure approaches an "ideal" bearing. Reference 3 presents an excellent account of distributed and self-compensated flexures.

**Flexure Contours:** Load capacity and maximum deflection depend strongly on the contour of the

<sup>1</sup>References are tabulated at end of article.

# VICTOR BILLIG

Research Engineer  
Research Laboratories  
United Aircraft Corp.  
East Hartford, Conn.

flexible connector. The types often used are the uniform cross section, Fig. 1 and 2, and the circular contour, Fig. 4 and 5. Or a combination of both can be used.

The simplicity of the circular contour, especially for transverse flexures, has encouraged considerable use of this type, even in situations which bear little resemblance to that shown in Fig. 4. However, in each case the basic circular profile, resulting from two parallel holes, can be identified. By proper selection of the location and orientation of these holes, flexibility may be obtained in almost any direction.

## Nomenclature

- $b$  = Flexure width, in.  
 $e$  = Flexure thickness, in.  
 $E$  = Modulus of elasticity, psi  
 $F$  = Side force, lb  
 $I$  = Moment of inertia at  $e$ , in.<sup>4</sup>  
 $M$  = Moment, lb-in.  
 $n$  = Increments of  $R$ , each of which equals  $R/25$   
 $P$  = Axial force, lb  
 $r$  = Length along flexure, in.  
 $R$  = Radius of circular flexure, in.  
 $S$  = Compliance factor, lb<sup>-1</sup>  
 $x$  = Moment arm of side force  $F$ , measured from center of  $R$ , in.  
 $\sigma$  = Normal stress, psi  
 $\theta$  = Angle of deflection, radians

## Subscripts

- $B$  = Bending  
 $D$  = Direct or axial  
 $min$  = Minimum  
 $o$  = Optimum

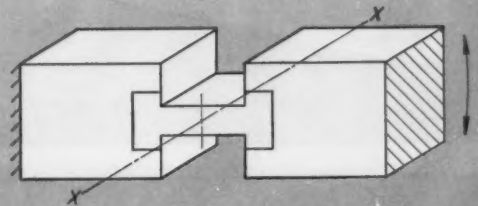


Fig. 1—Transverse flexure.

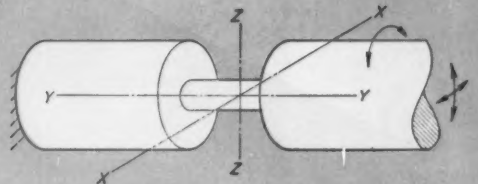


Fig. 2—Universal flexure.

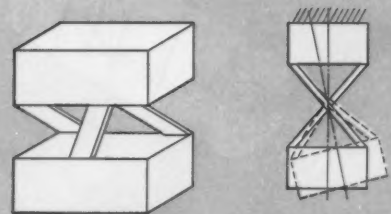


Fig. 3—Cross flexure.

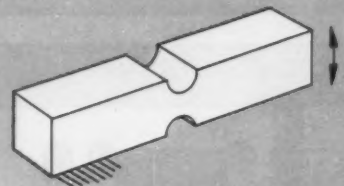


Fig. 4—Transverse circular flexure. Circular shape reduces stress concentration.

# FLEXURES

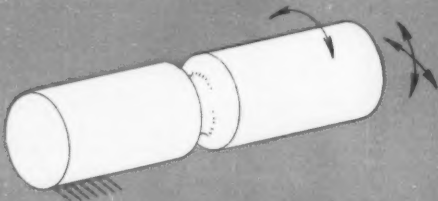


Fig. 5—Universal circular flexure.

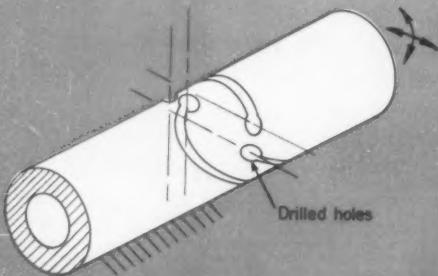


Fig. 6—Compound circular flexure.

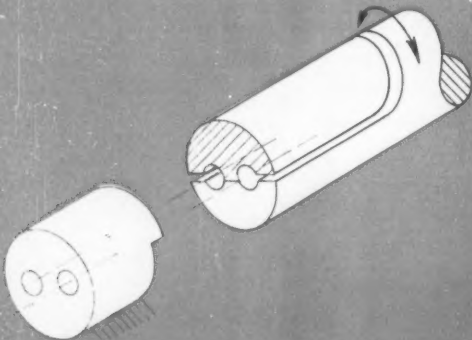


Fig. 7—Torsional flexure.

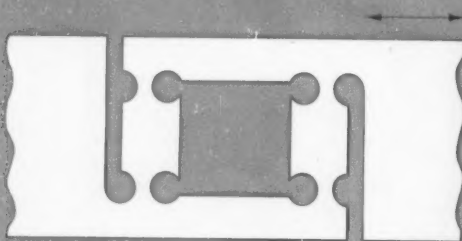


Fig. 8—Axial flexure.

In Fig. 6, two sets of perpendicular holes drilled at right angles to the axis of the shaft permit two-directional rotation about a point. If the shaft angle is small, a compound flexure of this kind may be used as a universal joint or as an internal bellows joint. Fig. 7 and 8 are configurations for torsional and axial motion.

In addition to their ease of manufacture, circular flexures offer several other advantages. Since they

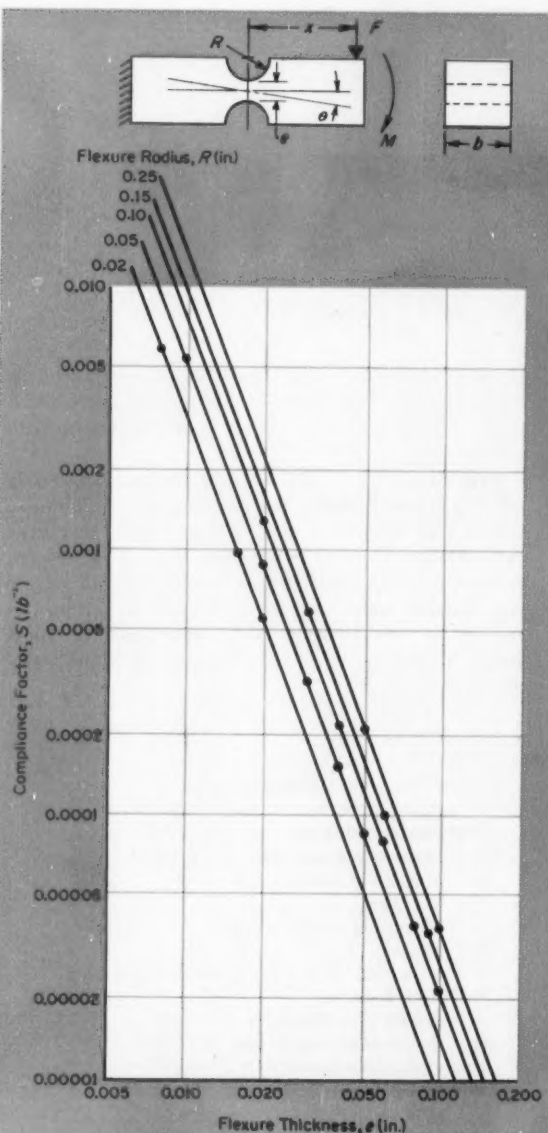


Fig. 9—Compliance  $S$  of transverse circular flexure in terms of flexure dimensions. Data were determined by computer solution of Equation 2.

are integral with the part, they suffer less from hysteresis effects than do built-up flexures. The gradual necking down of the flexible strip which separates the holes keeps stress concentrations to a minimum and provides good column stability under compressive loads.

A design procedure for transverse circular flexures is outlined here. The primary design criteria are deflection and stress.

**Deflection:** Fig. 9 shows the factors involved in the analysis. Deflection angle  $\theta$  may be determined from

$$\theta = 2 \int_0^R \frac{M + Fx}{EI} d\tau \quad (1)$$

where  $R < x$ . Variation in moment of inertia across the circular contour results in a nonintegrable ex-

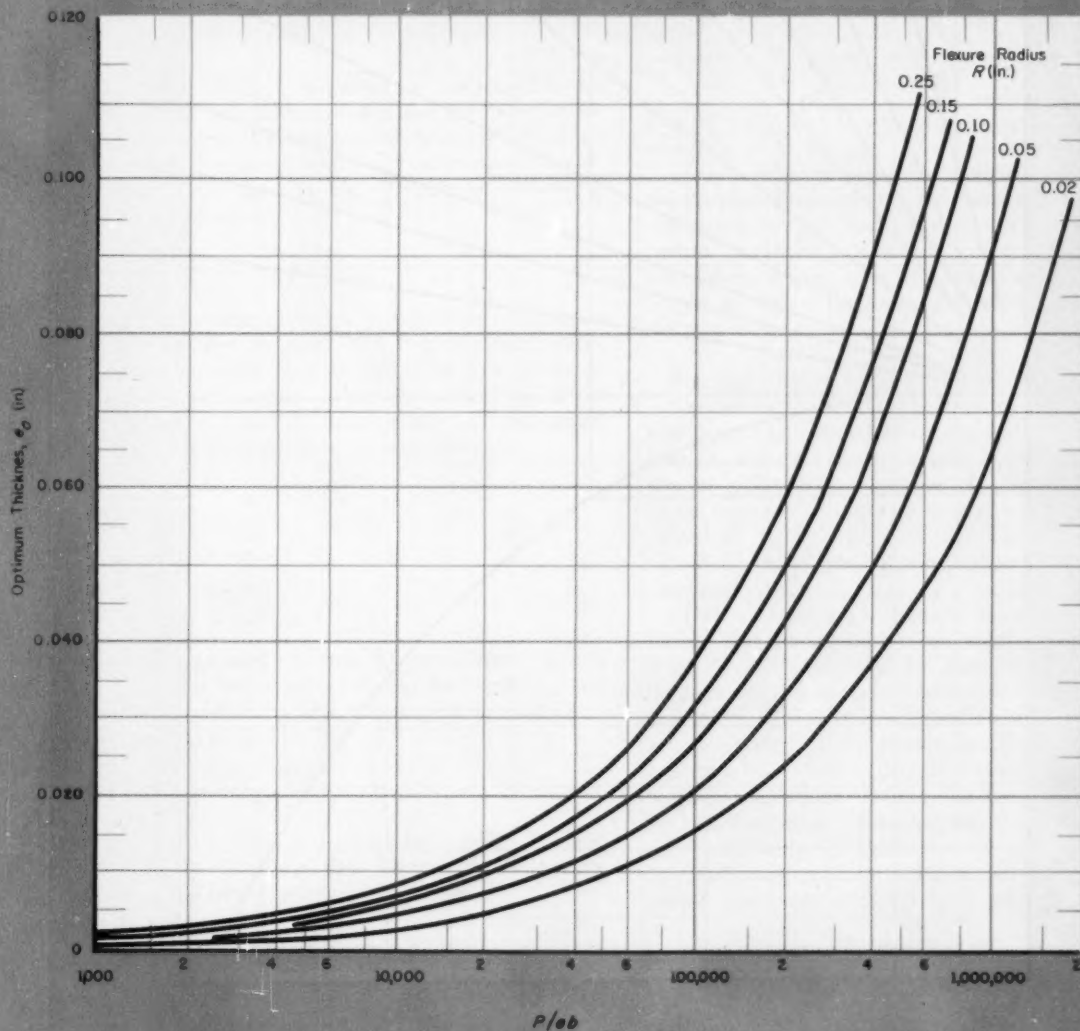


Fig. 10—Optimum thickness  $e_o$  for steel, transverse circular flexure (Equation 6).

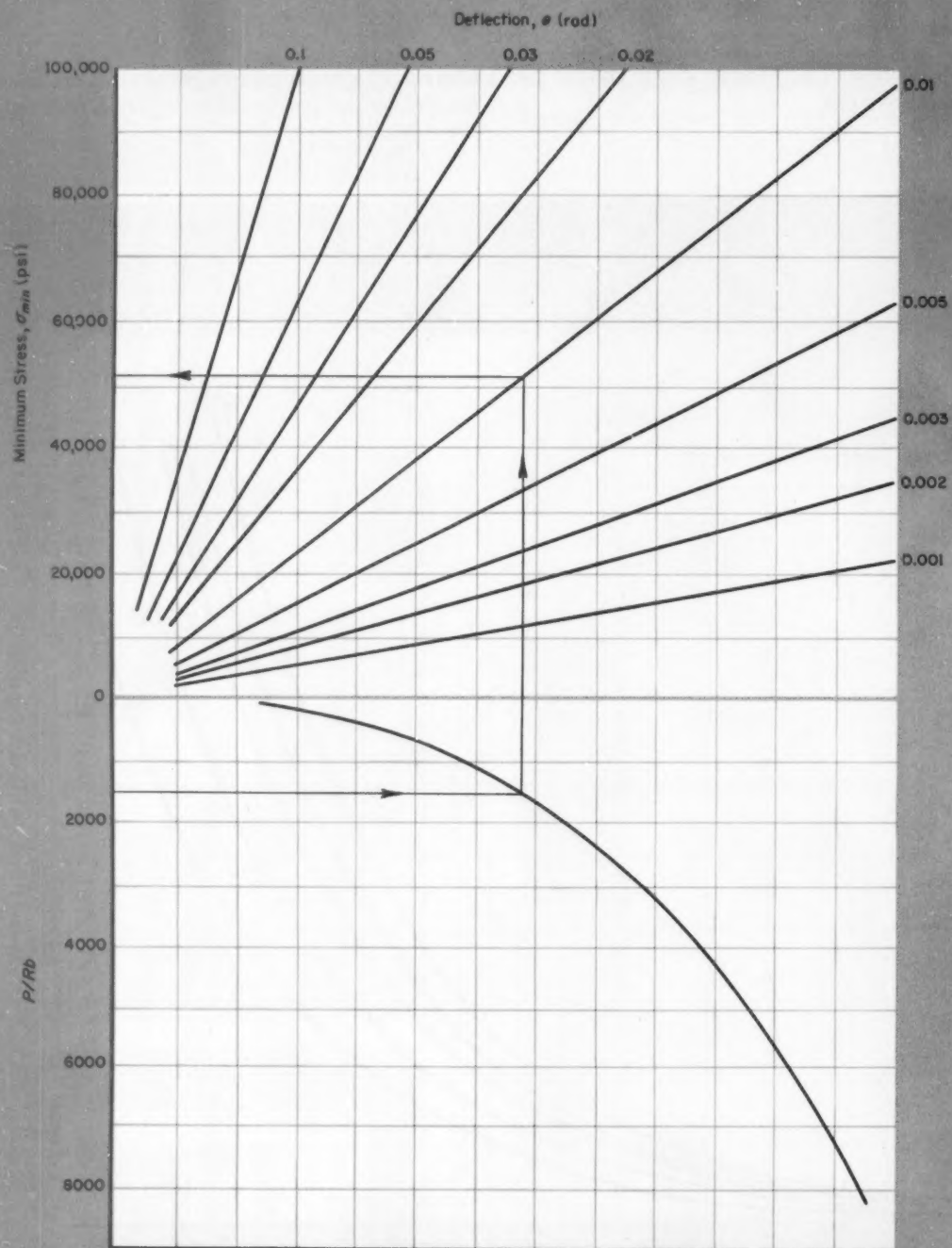


Fig. 11—Stress  $\sigma_{min}$  in flexure of thickness  $\epsilon$ , (Equation 7).

pression which was set up for solution on an IBM 704 computer.<sup>4</sup> For summation, length  $R$  was divided into 25 parts and values of  $R$  taken from 0.02 in. to 0.25 in. Then,

$$\frac{\theta}{2(M + Fx)} = \frac{12}{Eb} \times \sum_{n=0.5}^{n=24.5} \frac{R}{25 \left[ e + 2R \left( 1 - \sqrt{1 - \frac{n^2}{625}} \right) \right]^3} \quad (2)$$

Computations were carried out with a value of elasticity  $E$  applicable for steel. However, since deflection angles are inversely proportional to the actual elasticity, the results plotted in Fig. 9 are readily interpreted for any material. Compliance factor  $S$  is defined implicitly by

$$\theta = \frac{S}{b\mu} (2M + 2Fx) \quad (3)$$

where  $\mu = E/E_{\text{steel}}$ . In general,  $S$  is a function of  $e$  and  $R$ . The logarithmic plot of the computer results in Fig. 9 shows that the general form,  $S = Kf(R)e^p$ , represents the family of curves. Evaluating this equation with the data in Fig. 9 yields the following empirical equation:

$$S = 2.11 \times 10^{-7} \frac{R^{0.57}}{e^{2.57}} \quad (4)$$

**Stress:** In most instances it is possible to design a flexure so that an axial load  $P$  is the only active force which must be sustained. The total stress at the narrowest section is then the sum of the direct stress due to  $P$  and the bending stress at some angle  $\theta$ . Since the flexible section is rectangular,

$$\begin{aligned} \sigma &= \sigma_B + \sigma_D \\ &= \frac{3}{Se^2} + \frac{P}{be} \\ &= \frac{3\theta e^{0.57}}{(2.11 \times 10^{-7}) R^{0.57}} + \frac{P}{be} \end{aligned} \quad (5)$$

From this general equation for stress, the optimum size of  $e$  for minimum stress can be found. Taking the partial derivative of  $\sigma$  with respect to  $e$ , and setting it equal to zero,

$$e_o = \left[ \frac{1.24P \times 10^{-7} R^{0.57}}{\theta b} \right]^{0.637} \quad (6)$$

where  $P \neq 0$ . This result is plotted in Fig. 10. Substituting  $e_o$  into Equation 5 gives the minimum stress at the critical section of the flexure:

$$\sigma_{\min} = 2.406 \left( \frac{P}{Rb} \right)^{0.363} (\theta \times 10^7)^{0.637} \quad (7)$$

where again  $P \neq 0$ . Note that this equation applies only for an optimum selection of  $e$ , and that  $P$  is the sum of all possible direct loads that may act upon the flexure, including handling forces and dead weight. Side forces (transverse) resulting from bending are generally negligible. However, if no orientation of the flexure produces pure axial loading, an equivalent  $P$  must be found by tensor addi-

tion of shear produced by side force and normal stresses. A graphical representation of Equation 7 appears in Fig. 11. For design purposes,  $\sigma_{\min}$  should not exceed the allowable stress or the endurance limit of the material.

**Example:** A transverse circular flexure is required to support an axial load of 400 lb and permit lateral oscillation of  $\pm 0.2$  in. at the end of a 20-in. steel suspension rod. The rod is 1 1/16 in. square.

Since the design equations hold only if the center of radius  $R$  falls on or within the boundary of the rod,  $R$  must be less than one-half of the rod thickness. Assume  $R = 0.250$  in. Then, for use in Fig. 10 and 11,

$$\theta = \frac{0.2}{20} = 0.01 \text{ radian}$$

$$\frac{P}{eb} = \frac{400}{0.01(1.0625)} = 37,600$$

$$\frac{P}{Rb} = \frac{400}{0.250(1.0625)} = 1500$$

From Fig. 10 and 11, thickness  $e_o = 0.020$  in. and stress  $\sigma_{\min} = 51,000$  psi.

These results complete the "optimum" solution to the problem. However, if other factors dictate different proportions, so that the design is no longer optimum, Equations 3, 4, and 5 can be used to calculate deflection and stress. Also, these same equations can be applied to the analysis of existing flexures of the type shown in Fig. 9.

**Practical Design Factors:** Stiffness of a flexure is influenced by the ratio of thickness to length. Thickness cannot be reduced freely without compromising strength. However, flexibility can be gained by addition of a flat section between the circular portions of the contour. In this case, a trial-and-error design procedure is usually required. Column stability should be investigated if the flexure is subjected to compression.

In view of the high stresses, the machining of a flexure and the selection of an appropriate material deserve careful attention. For high-strength flexures, hardenable alloy steels such as AMS 6370, AMS 6322, and AMS 6415 give good results. In one common processing method, the flexures are rough-machined, heat-treated to Rockwell C 36-40, and then ground to final dimensions. Fatigue life may be improved by case hardening. However, this treatment is recommended only for thicknesses greater than 0.030 in. Tool marks and surface scratches should be removed and precautions taken to prevent corrosion.

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# Evaluating

Present-day designs use metals at high efficiency—in thin sections, and at high stresses and temperatures. Under these conditions, old “reliable” properties tests are often not reliable. New tests are needed to handle such sophisticated problems as sheet steels used under biaxial stresses.

**S**TANDARD mechanical properties tests—yield strength, creep strength, fatigue strength, etc.—are important for evaluating materials, and the correct interpretation of data obtained from these tests often helps to improve designs. But if the materials are subjected to biaxial stresses, new problems are introduced. Uniaxial tests cannot predict biaxial performance.

Sophisticated tests have been developed to help solve these critical stress problems. For instance, high-strength sheet steels for thin-wall pressure vessels (rocket fuel tanks) are used under biaxial stress conditions at high temperatures. Before metals for this kind of application are evaluated at high temperatures,\* their behavior under complex loadings at room temperature should be observed.

The two most important criteria for this analysis are notch and fracture toughness.

**Significance of Notch Tests:** Stress concentration and notch sensitivity are not confined to impact tests. Notches affect every type of loading and are now commonly applied to tensile, fatigue, and stress-rupture tests. When a notched bar is pulled in pure tension, biaxial stresses developed at the notch bottom restrict plastic flow. About 1.5 times as much stress is required to produce a given contraction in

\*E. A. Loria—“Evaluating High-Temperature Materials,” *MACHINE DESIGN*, May 28, 1959, pp. 121-125.

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# High-Strength Steels

*... under complex loading*

area in the notched specimen as in the unnotched specimen of the same cross section. At relatively low strength levels where steels have high notch ductility, the notch strength is about 1.5 times the tensile strength. At high strength levels where notch ductility is low, the notch strength may be as much as 30 per cent less than the tensile strength.

This relationship of notch strength versus tensile strength for conventional low-alloy steels is shown in Fig. 1. Up to 190,000-psi tensile-strength level, notch strength is approximately 1.5 times the tensile strength. Above this level, the amount of deviation increases with increasing tensile strength. Different steels deviate at different rates, so there may be wide differences in notch strength for a given high level of tensile strength. At the 230,000-psi tensile strength, for example, the notch strength for the eight steels varies over the range 130,000 to 300,000 psi.

These steels do not develop sufficient strength to satisfy the designers of advanced aircraft and missiles. But a number of steels formerly used in other applications and newly devised analyses are now under study. The objective is to achieve ultrahigh tensile strength with some measure of ductility. The relationship between notch strength and tensile strength in this ultrahigh-strength area is illustrated in Fig. 2. The aim is to raise the quality level of appropriate steels to the theoretical upper limit by

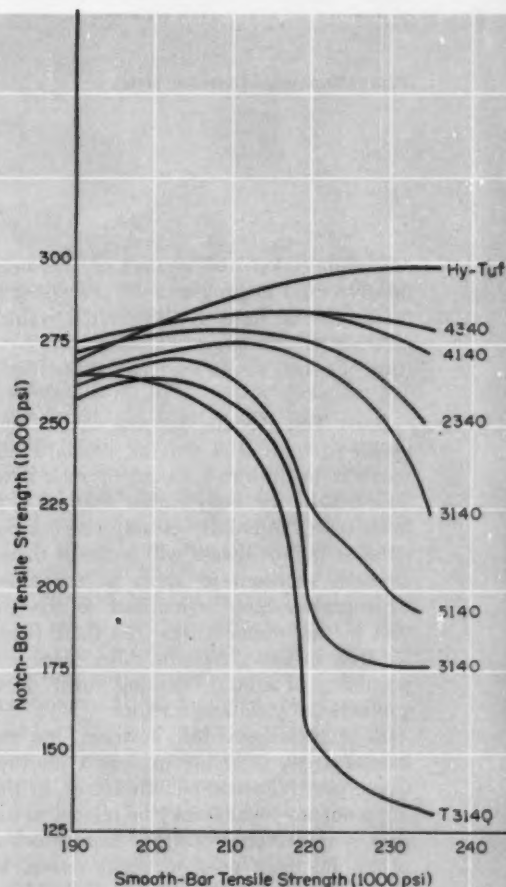


Fig. 1—Notch-bar and smooth-bar tensile-strength ratio varies considerably for low-alloy steels beyond the 190,000-psi tensile-strength level.

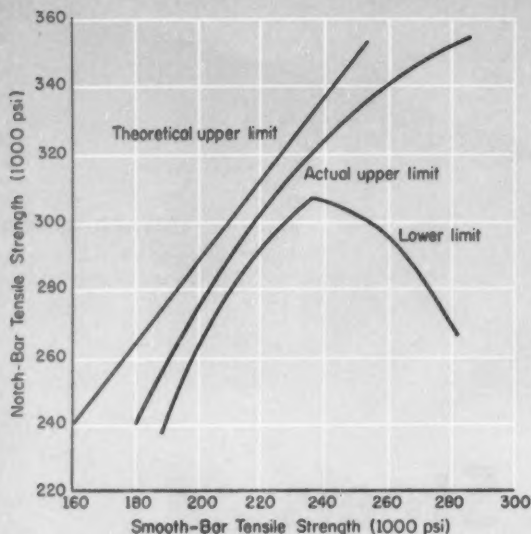


Fig. 2—At the ultrahigh-strength level, there can be a highly significant difference in notch strength for a given tensile strength.

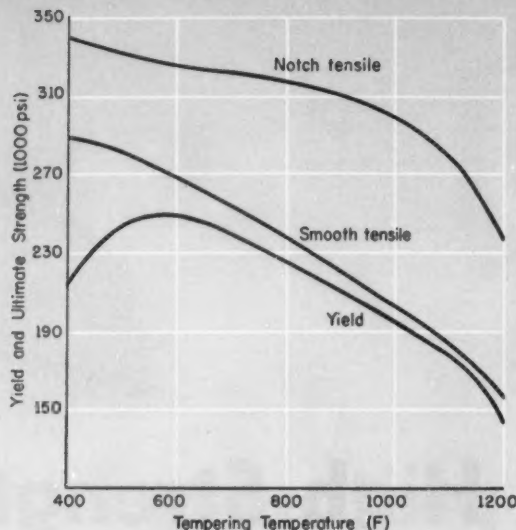


Fig. 3—Careful selection and control of steel processing and composition gives promise of better quality level of steels, as shown by tests on Ladish D6.

#### EVALUATING HIGH-STRENGTH STEELS

careful selection and control of the steel composition, vacuum melting and all processing that would possibly contribute to the desired result. There is promise in this approach as shown by recent results obtained on at least one steel, Fig. 3.

**Burst Test Results:** Suppose that a high ultimate tensile-strength steel (in the standard ASTM specimen) is made into a vessel in such a way that it fractures in the body rather than in a joint when burst under internal pressure. The computed tensile stress at failure always will be lower than the tensile strength supposed to apply to the material itself. This phenomenon is ascribed to the circumstance that in the simple tension test there is some chance for flow in two directions. Also, there is always the possibility of a little "necking down" in the narrow gap between yield and fracture.

In a pressure vessel, however, the metal resists biaxial stress, so ability to flow is sharply restricted. Consequently, attention is directed to the "shattering tendency" which may be related to the ability to stop a crack, once started. Also, much reliance is placed on burst tests on small vessels, not only to determine the actual strength of the sheet steel, but also the effect of minor variations and adjustments in manufacturing techniques.

In welded pressure vessels, catastrophic failures at stresses below designers' expectations can occur in welds and heat-affected zones. Standard tensile, bend, and impact tests do not reveal this possibility, and it is necessary to build small vessels to learn the

welding qualities of various steels. These models are hardened and tempered at different temperatures, along with control specimens of base metal and transverse welds. Tension test results are then compared with the bursting-pressure results.

There is no correlation between yield strength and elongation measured in a tension test, and the behavior of a material in a pressure-vessel application, Fig. 4. The difference in tempering temperature for maximum strength and for maximum bursting pressure is attributed to low ductility and notch sensitivity of this H-11 type steel at the highest strength level. However, at lower strength or hardness levels, the steel performs satisfactorily.

Smooth or notched tensile-test properties are generally measured in specimens which have their lengths in the direction of rolling of the sheets. Transverse specimens would very likely give inferior results. But it is considered more important to determine longitudinal properties because the sheet is usually oriented in a fabricated pressure vessel so that the hoop stress acts in the direction of rolling. The calculated hoop stress due to internal pressure in a cylindrical, thin-walled vessel is twice the longitudinal stress. Apart from bending moments, the stress across the direction of rolling is only one-half of the stress along the direction of rolling. Fracture of such vessels tends to run in the longitudinal direction, perpendicular to the hoop stress.

There is some evidence that beyond a certain hardness and strength level, pressure-vessel tanks lose

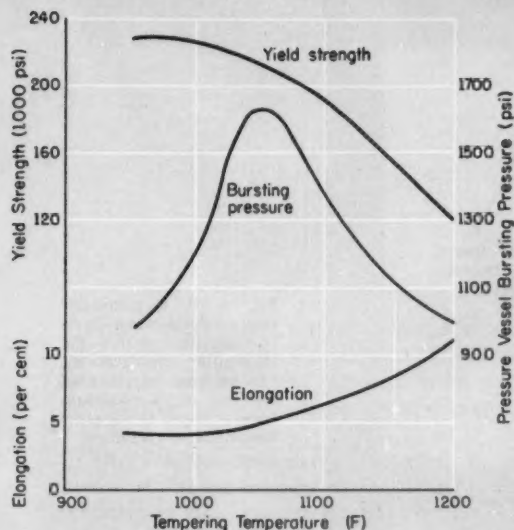


Fig. 4—Maximum yield strength, bursting pressure, and elongation occur at different tempering temperatures. Data are for 0.025-in. thick Vascojet 1000. (Courtesy Martin Co.)

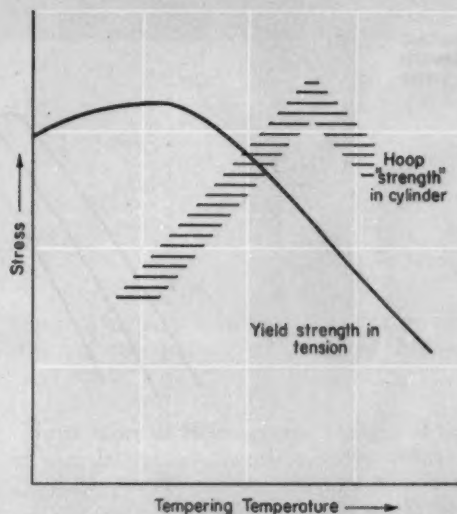


Fig. 5—Yield strength in tension reaches its maximum at a lower tempering temperature than hoop "strength" of material in a cylinder.

all ductility. Model tanks of H-11 type steel, heat treated to Rockwell C 52 hardness, resist a hoop stress of 265,000 psi. But at Rockwell C 56 hardness, transgranular failures occur at stresses as low as 150,000 psi.

The relationships between tensile yield strength, hoop "strength," and tempering temperature are generalized in Fig. 5. This situation is the reason for the inadequacy of most steels heat treated above 210,000-psi yield strength in a welded construction.

Another disturbing factor that points out the necessity for having closely controlled and uniform chemistry is that the optimum tempering temperature can vary from heat to heat, Fig. 6. Indeed, results can vary considerably with the cleanliness of the alloy, and with minor variations in the chemical analyses even within the spread allowable in the specification.

**Interpretation of Net Fracture Stress:** Because thin-wall pressure vessels have failed with a brittle fracture, great emphasis has been placed on measuring fracture toughness by a laboratory test. The Naval Research Laboratory developed a test for studying the crack-propagation resistance of high-strength steels. This method consists of comparing the ultimate strength determined in a standard tension test with the strength of a notched specimen (crack or slot).

The net-fracture stress,  $F_n$ , of the cracked specimen is calculated by  $F_n = P/t(b - c)$ , where  $P$

= maximum load, lb;  $t$  = specimen thickness, in.;  $b$  = specimen width = 0.5 in.;  $c$  = length of the initial crack, in. The cracked-specimen strength ratio is based on  $C = F_n/F_{tu}$ , where  $F_{tu}$  = tensile strength of the standard tension specimen. Ratio  $C$  is considered an indication of the crack-propagation resistance of a material.

Since pressure-vessel bursting pressure is believed to depend upon resistance to crack propagation of the steel, such a test should be useful for predicting how a material will behave in a pressure-vessel application. Fig. 7 shows how ratio  $C$  varies with tempering temperature for H-11 steel. The ratio of pressure-vessel bursting pressure to calculated bursting pressure for model vessels is also shown. On the basis of these curves, there appears to be a definite correlation between the two tests.

The current approach lies in the proper interpretation of the net-fracture stress, defined as the maximum load divided by the initial net supporting area normal to the direction of application of the load. It is, therefore, analogous to the ultimate strength of an ordinary tensile specimen, and to the notch strength of a specimen notched at the edges.

It is apparent that  $F_n$  will depend not only on the properties of the steel but also upon the specimen width,  $b$ , and the length of the starting crack or slot,  $c$  (assuming that thickness, temperature and rate of loading are not varied). Thus, it is an arbitrary value which represents the effect of a particular "size" of stress-concentrating defect.

Transition temperatures are determined for net-

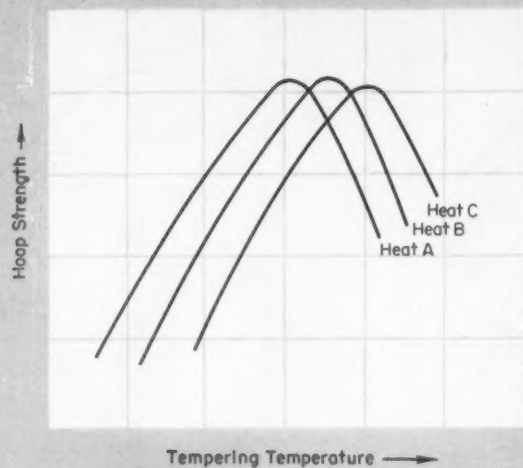


Fig. 6—If a particular steel analysis is not closely controlled within the allowable specifications, various heats of the steel may not reach maximum hoop strength at the same tempering temperature.

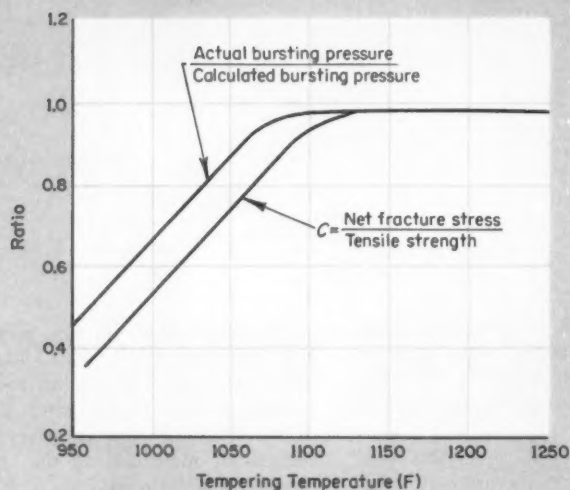


Fig. 7—Cracked-specimen strength ratio,  $C$ , computed from data on standard specimens, Vascojet 1000, correlates well with ratio of actual to calculated bursting strength of material, and may be a good predictor of burst strength. (Data, courtesy Martin Co.)

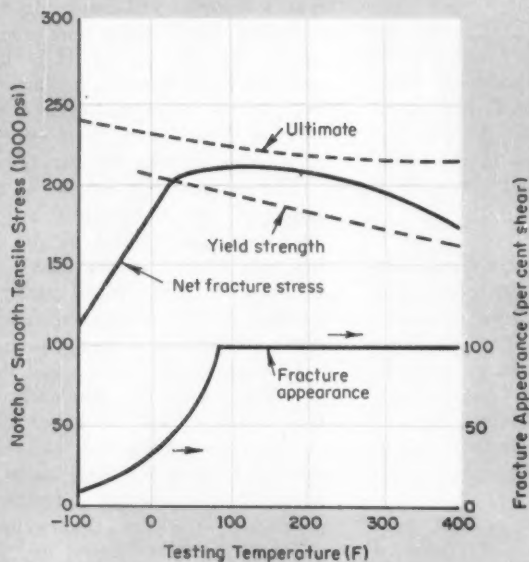


Fig. 8—Fracture appearance and net fracture stress criteria delineate the fracture toughness of high-strength steel, Air-steel X-200. (After Srawley and Beachem.)

fracture stress and fracture appearance, and such values are used to evaluate various steels. NFSTT is defined as the lowest temperature at which the net-fracture stress equals the yield strength.

**The Fracture-Appearance Criterion:** In conjunction with the net-fracture stress, the Naval Research Laboratory uses the fracture-appearance transition temperature as a criterion of the suitability of a material. The principal basis for this preference is the expectation that the fracture appearance will depend much less on specimen geometry (except thickness) than on stress at failure.

FATT is the lowest temperature at which the mode of fracture is entirely oblique or 100 per cent shear. At this temperature, the toughness of the material to be used in a structure (where the nominal stresses may reach the yield strength) will be properly measured. However, it is sometimes difficult to determine this temperature with precision when the ratio of specimen width to thickness is low. Hence, a slightly less conservative criterion, 50 per cent shear, together with a margin of safety in temperature has been suggested.

The FATT provides a very simple basis for selection of materials: If, for the thickness required in the contemplated application, the FATT is above the lowest anticipated service temperature, the steel should be rejected. Since a particular steel composition can be heat treated or otherwise processed to provide a range of properties, the FATT can be used to establish the maximum usable tensile yield strength for a given steel in a given application. Different steels can then be compared on the basis of their respective maximum usable tensile yield strengths.

How the FATT and the NFSTT delineate the fracture toughness of a high-strength steel is shown in Fig. 8. On double tempering for 2 hr at 1000 F, tensile strength of this steel at room temperature was 223,000 psi; 0.2 per cent yield strength was 198,500 psi; and elongation in 2 in. was 7.5 per cent. The FATT is 90 F and, in this case, the NFSTT is well defined at 25 F.

Even in this condition, with the yield strength slightly less than 200,000 psi, the steel cannot be said to be suitable for use at room temperature because the FATT is higher than room temperature. At room temperature the fracture appearance was about 80 per cent shear. The extended double tempering at 1000 F (compared with 30-minute single tempering) had no appreciable effect on the yield strength and little on the ultimate strength or elongation. But it did produce quite significant changes in fracture appearance and net-fracture

stress. This may be a useful clue to the improvement of the fracture toughness of high-strength sheet steels.

**Importance of Homogeneous Design:** If the effect of the largest stress-concentrating defect in the structure is less than the crack or slot in the test specimen, the results of the tests should be a safe guide to the performance of the structure. They may even be excessively safe. It should be noted that the largest stress-concentrating defect should be taken as the smallest which can be detected with acceptable confidence by the inspection procedures. Inspection and quality control, therefore, determine an essential design factor.

Geometric irregularities can be as potent as metallurgical irregularities in reducing the service capabilities of rocket fuel tanks and similar containers. A homogeneous design must be realized. It should consist of components that are compatible with one another in strength, section size, and stretching capabilities.

Failures can occur from such simple errors as building a high-strength chamber which does not withstand  $\frac{1}{4}$  in. stretching during pressurizing. Heavy changes in section between one area and another can produce problems. Portions which have too much metal may be more dangerous than the regions which are underdesigned. Better results are obtained by utilizing better stress analyses, enabling the use of less severely stressed metal.

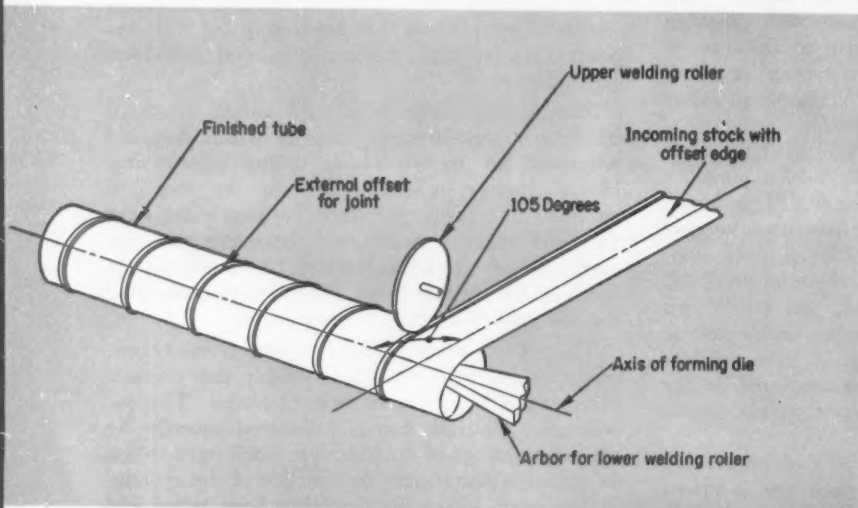
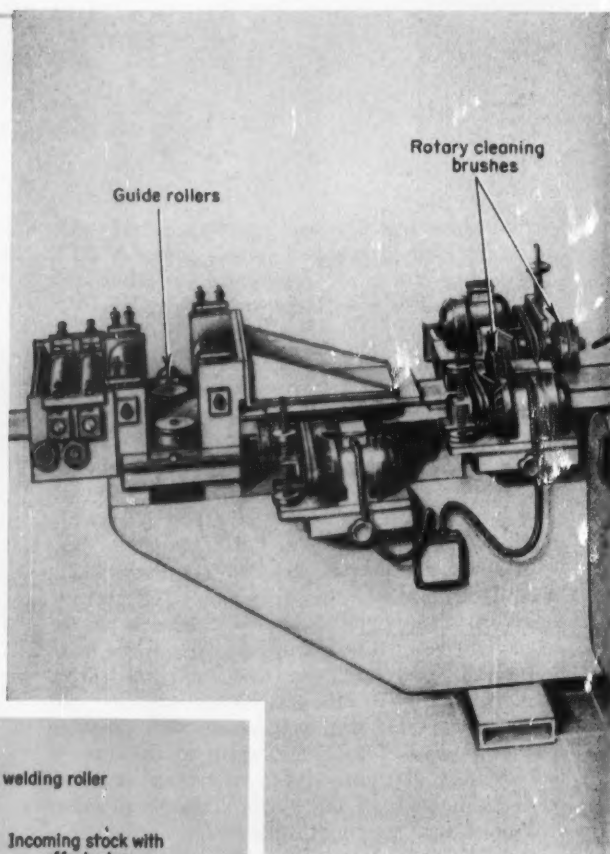
The second matter that has always been considered is the well-known relationship that pressure times radius equals stress times thickness. This relationship is valid, but is influenced severely by the exact contour of the chamber. Such small things as getting a flat surface on one side of the cylinder at the point where the sheet has been rolled and welded can lower the burst stress markedly. This flat area can increase the strain by 50 to 75 per cent.

Another situation would be the attainment of an ellipsoid on the aft section where the curvature is conical instead of round. Although the deviation in length is hardly noticeable, it can multiply the stress by a factor of 2 or maybe more.

Therefore, the second important factor is that the performance analysis must be based on the geometry attained in the fabrication of the cylinder, and not what one hopes or thinks he is getting. Distortion due to heat treatment, and geometric flaws—in other words, problems beside the metal itself—create the results realized in many tests.

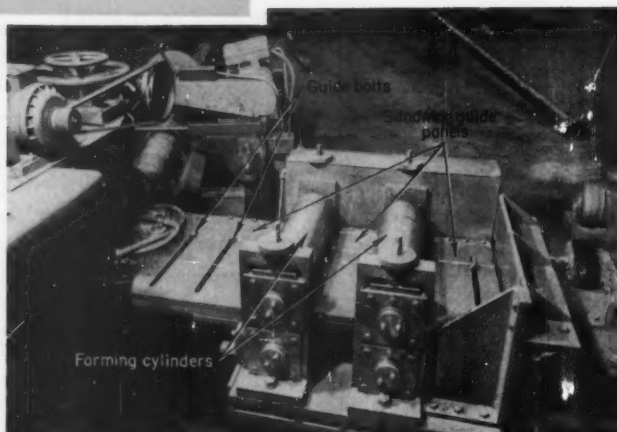
## Die Position Controls Helix Pitch in Endless-Tube Machine

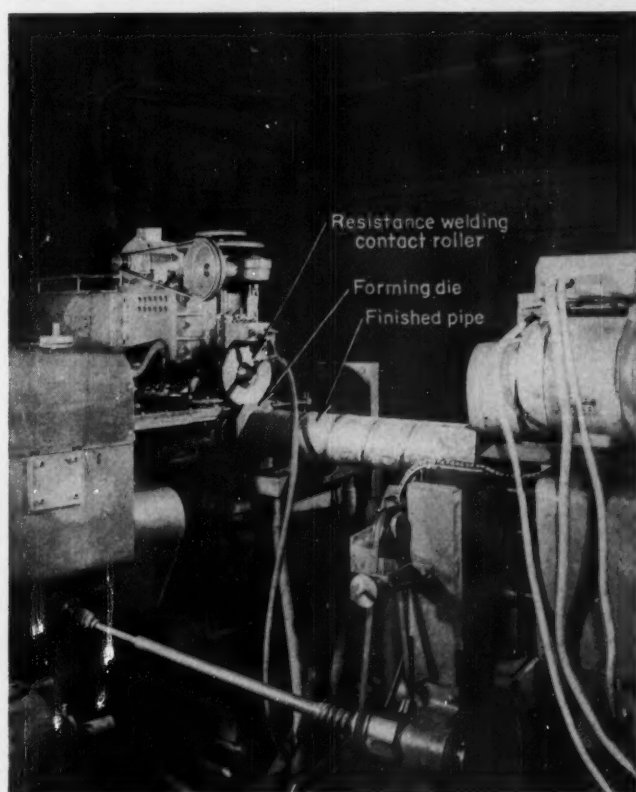
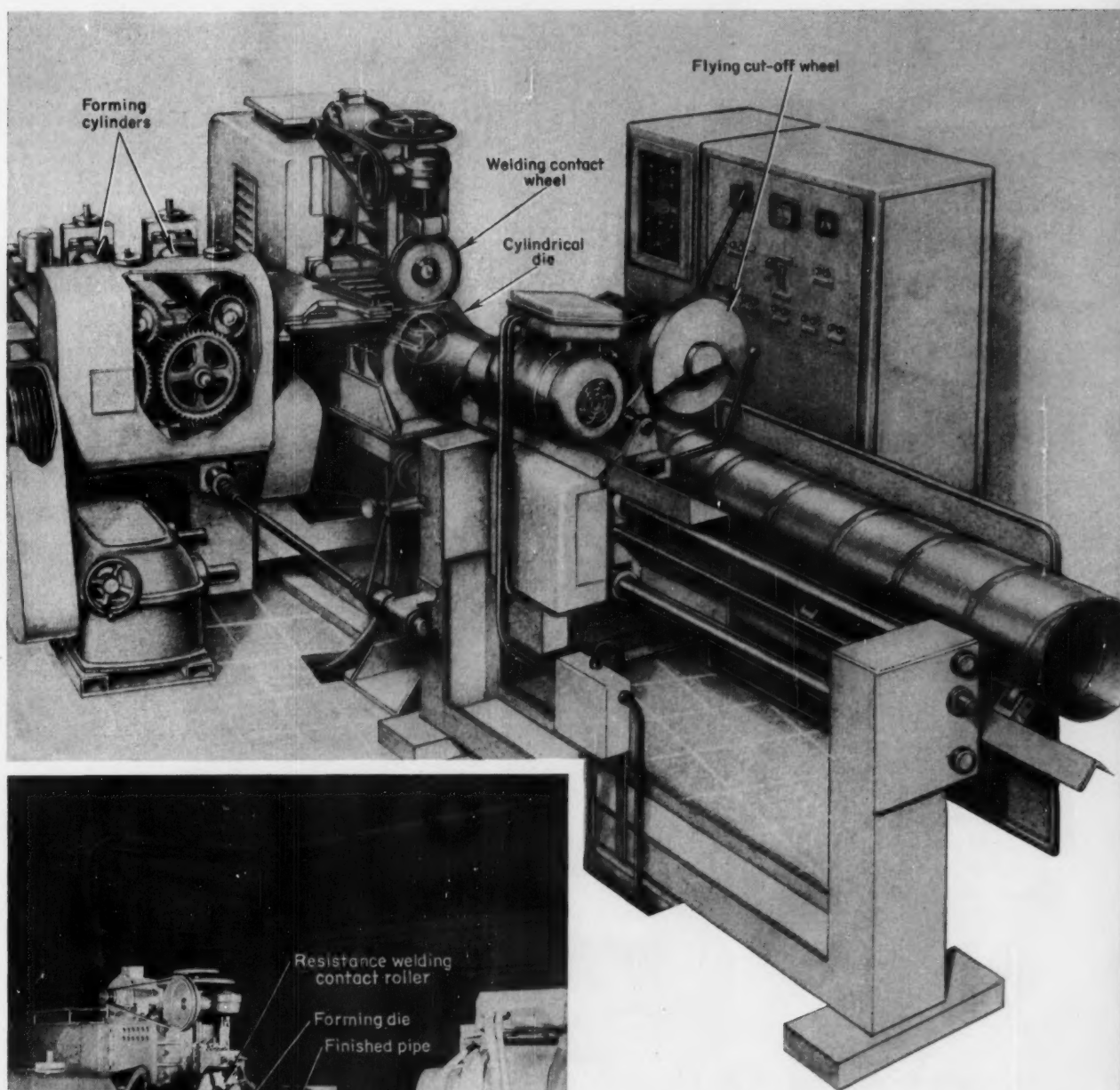
**AXIS OF CYLINDRICAL FORMING DIE** is positioned at 105 degrees from the path of incoming stock in a continuous tube producing machine. Pitch of the spiral formed by this angle is less than one diameter. The machine's product is exceptionally strong tube using the spiral weld as reinforcement.



**GUIDE ROLLERS POSITION** the stock entering the machine and rotary brushes thoroughly clean the edges to be welded.

**STOCK GUIDES** are adjusted to proper width for strip stock by bolts in slots of sandwich guide panels. The stock passes between the panels. Forming cylinders roll an offset into the right edge of the stock. This makes possible a smooth pipe interior for minimum loss of head.

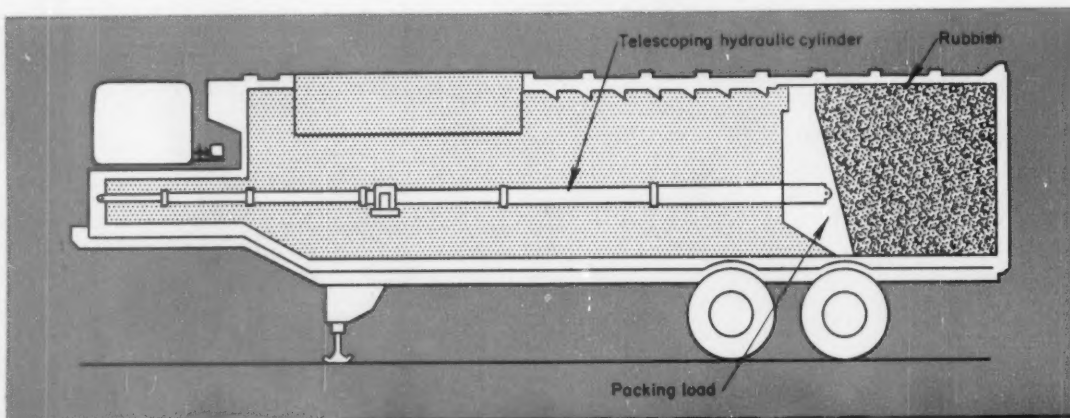




Fovard process for making pipe in a single machine is patented in 18 countries. Holder of manufacturing rights, the Societe Helicotube, Saint Egreve, France, builds and uses the pipe-making machines in its own factories around Grenoble.

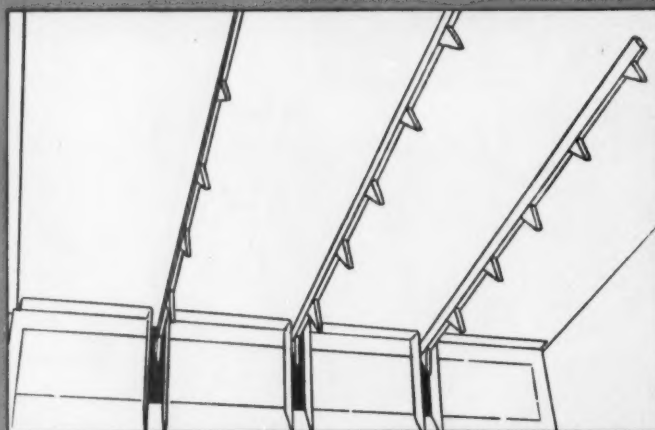
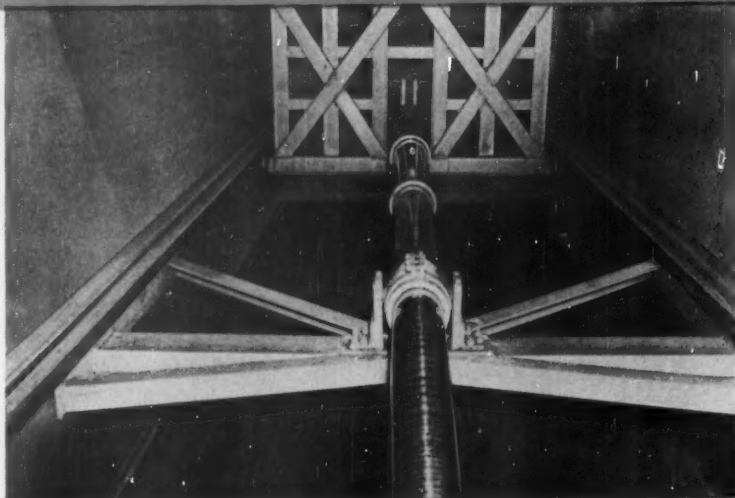
**WELDING IS DONE** as pipe is formed. Strip moves axially in one revolution a distance equivalent to the width of the stock; left edge fits neatly into the offset right edge where it is welded.

## Hydraulic Ram Packs Rubbish

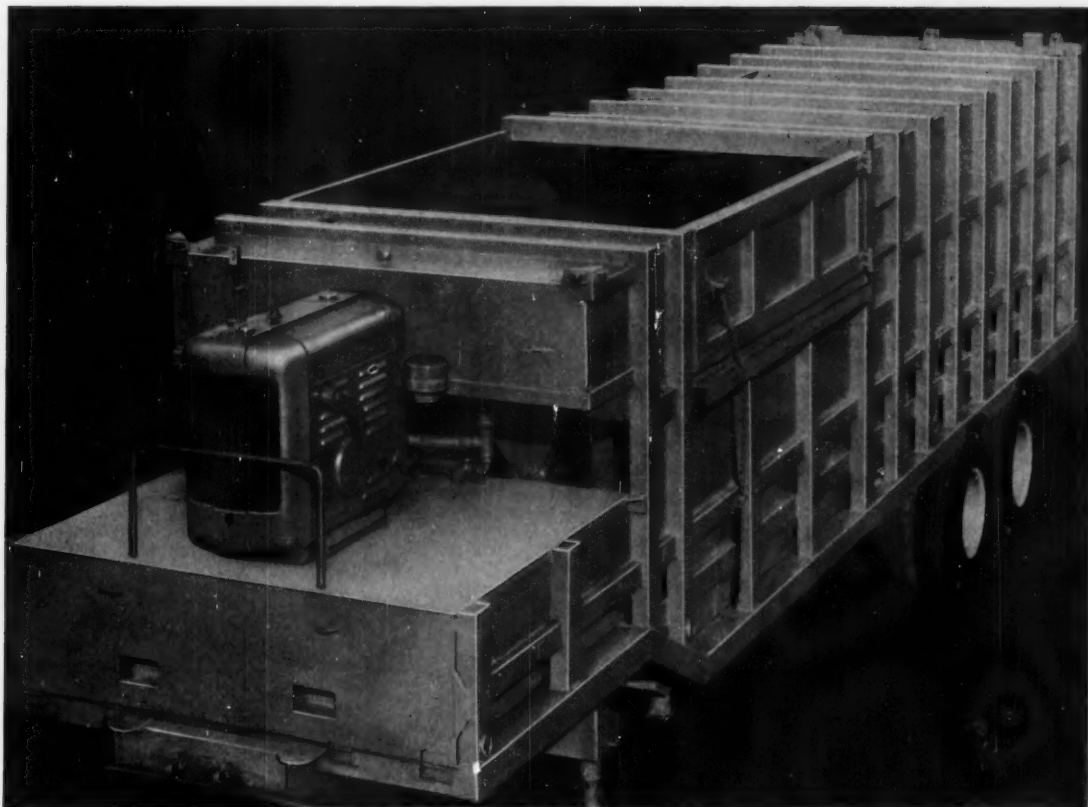


**TELESCOPING HYDRAULIC CYLINDER** furnishes the packing head of a new refuse trailer with 300 in. of travel and more than 3 tons of total thrust. Refuse dumped into the hopper opening at the forward end is compacted to as little as one-fourth of its bulk. Wet refuse is collected in an 18-gal sump.

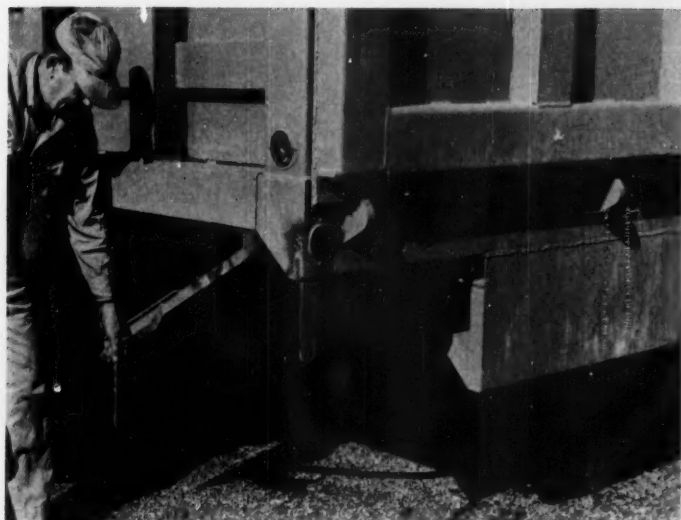
**ROWS OF RETAINING TEETH** keep compressed load from springing back when packing head is retracted. Slots in the head pass the teeth easily.



## in Disposal Trailer



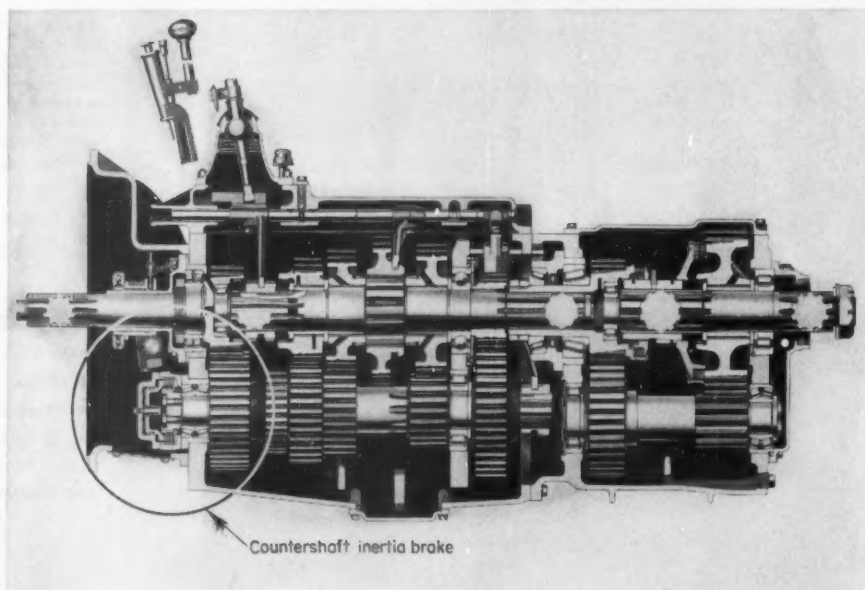
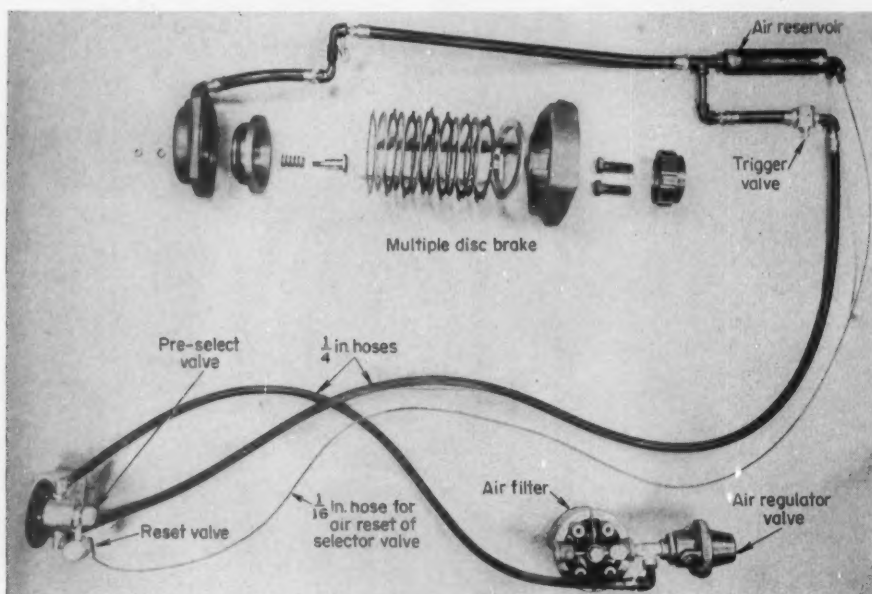
Compaction Trailer is powered by a 50-gal hydraulic pump driven by a Continental 50-hp gasoline engine at a constant speed of 1800 rpm. A single two-position lever near the motor controls forward and back motion of the packing head. The trailer is built by Dempster Brothers, Knoxville, Tenn.



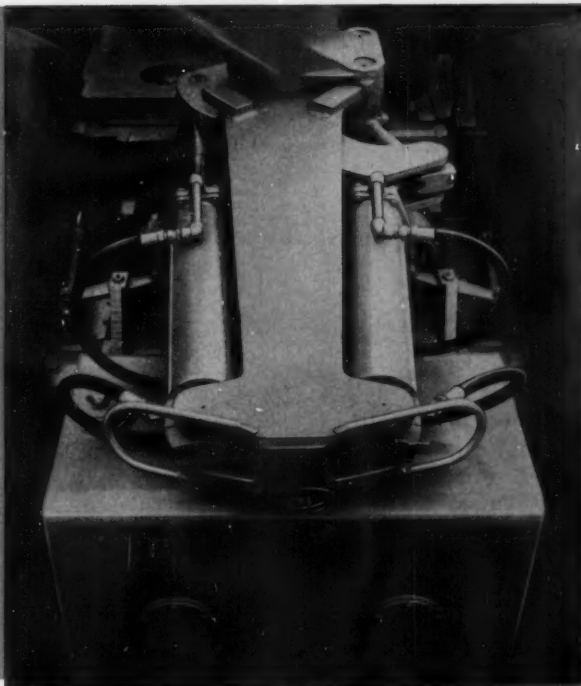
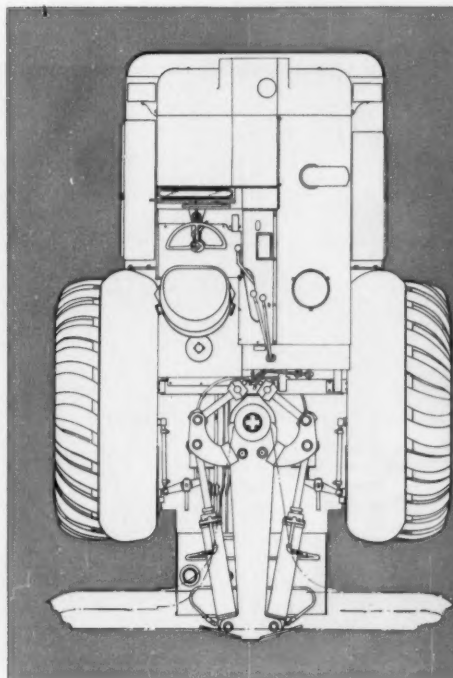
**HOOKS HOLD DISCHARGE DOOR** securely in place during loading operation; they are released manually for dumping by pushing a lever on the side of the truck. Hydraulic ram pushes refuse through the top-hinged door.

## Inertia Brake Eliminates Double Clutching

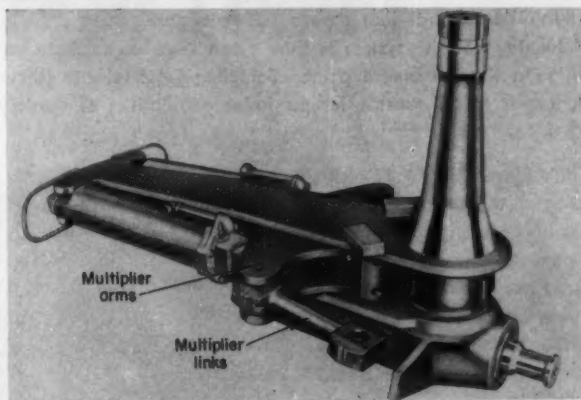
**TRIGGERED BRIEFLY** while the gearshift lever is in neutral position, an air brake stops overspin of the transmission countershaft more effectively than double clutching in a new earthmoving unit. A preselect valve button on the dash allows the brake to be used only when chosen by the operator. Brake is automatically disengaged when the lever is shifted out of neutral. The Countershaft Inertia Brake was developed for Allis-Chalmers by Fuller Manufacturing Co., Kalamazoo, Mich.



## During Shifting in New Motor Scraper



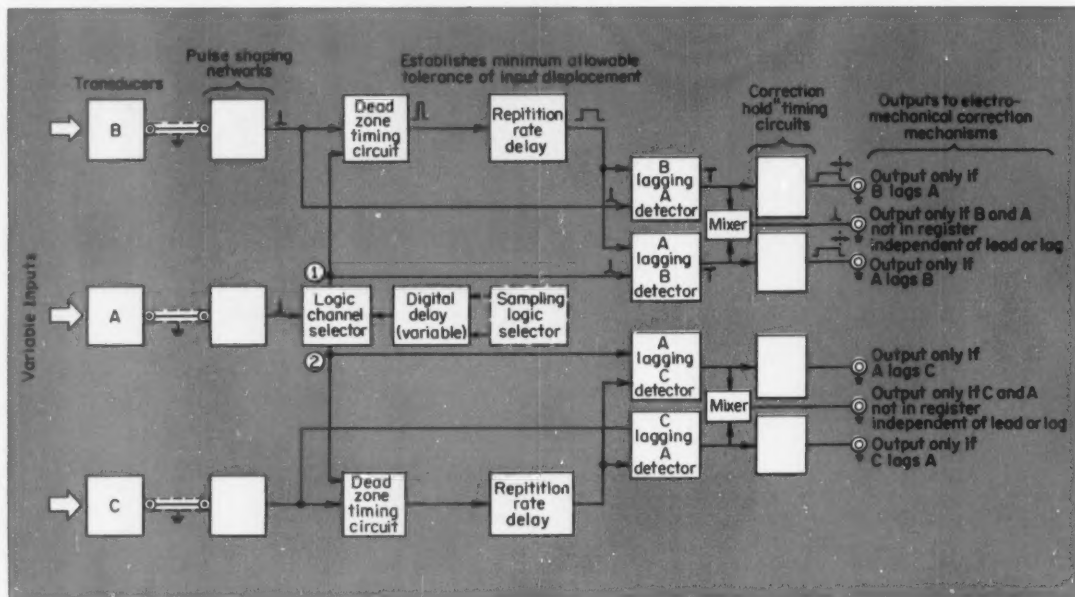
**TRACTOR IS JACKED** around steering post by double-acting hydraulic pistons. A system of multiplier links and arms gives the pistons about the same mechanical advantage in full turn as in straight-away position. A one-sixth turn of the steering wheel puts full hydraulic power on the jacks. Fine steering control can be achieved by smaller turns of the wheel. Tandem pumps supply scraper and steering jacks, so full power is available to each system during simultaneous scraping and steering.



Motor scraper, developed by Allis Chalmers Manufacturing Co., Milwaukee, Wisconsin, hauls 22 cu yd struck load. The turbocharged 340-hp engine delivers hydraulic power for steering, scraping, and ejection of material. A torque-control differential divides torque between drive wheels in proportion to traction available. Foot-pedal-controlled four-wheel air brakes add to the safety of operation. It's listed as the TS-360 motor scraper.

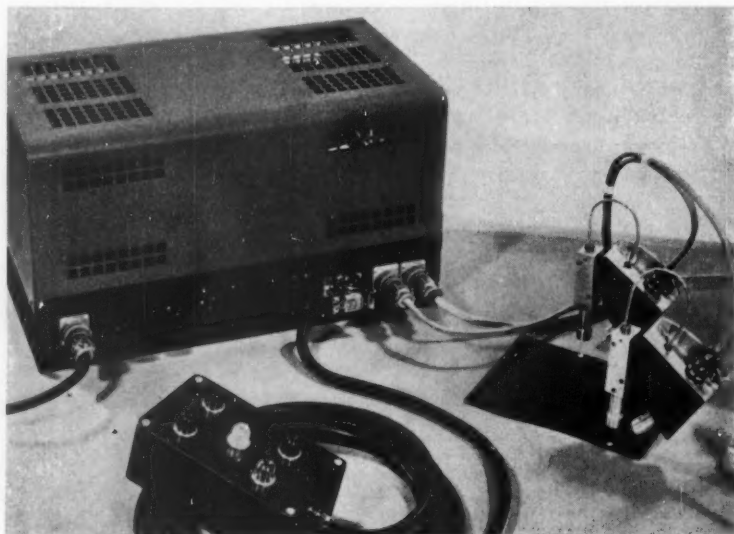


## Interlocked Circuits Hold Variables In Register Without Fixed Reference



**REGISTRATION MARKS** of various types are quickly and accurately aligned by a dual registration control that uses a self-balancing system of four interlocked servo circuits. Advantage of the system is that it can keep up to three variables in register without using a fixed reference point. Sampling logic selector (shown in dashed lines) is custom-built to compensate for particular peculiarities of user's jobs.

**TRANSDUCERS MAY BE** photoelectric, magnetic, or mechanical depending on the demands of a particular job. Inputs may also come directly from an automatically indexing machine. Visual indication of register condition is supplied by the remote indicator station in the foreground. It's used to double-check the machine and make fine adjustments when starting. Dual registration system was developed by Sterns Control Corp., Great Neck, New York.



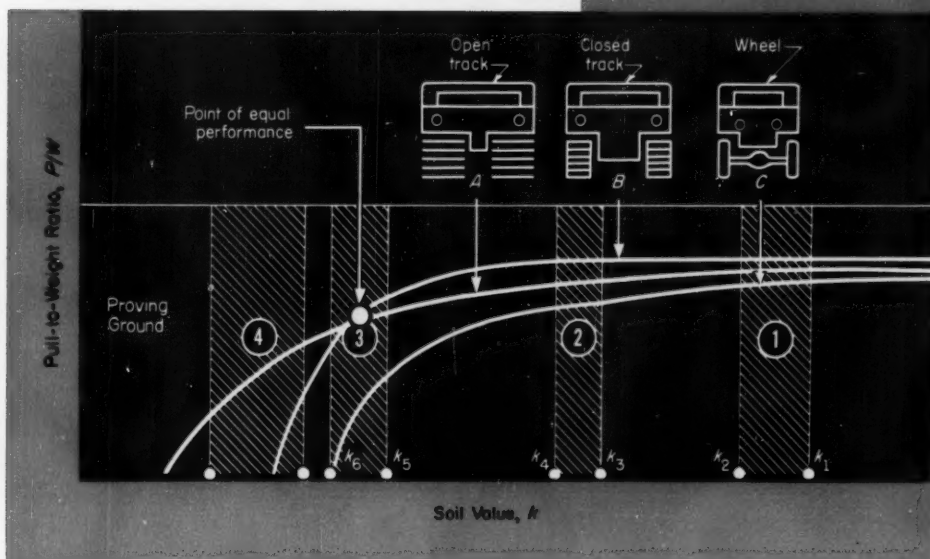


Fig. 1—Points of equal vehicle mobility are obtained from intersection of performance curves.

## Optimum Performance and Future Trends

### M. G. BEKKER

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TODAY'S attempts to determine the degree of mobility improvement are performed only at the proving grounds. However, soil values are rarely measured during such tests. In addition, proving grounds are seldom selected on the basis of quantitative terrain analyses and statistical sampling techniques. Hence, truly "average characteristics" of the potential terrain of operations are seldom obtained. As a result, any optimum measurements of the drawbar pull, or other performance factors, reflect those unknown values of cohesive modulus  $k_c$ , frictional modulus  $k_\phi$ , exponent  $n$ , cohesion  $c$ , and friction  $\phi$  that happen to exist at the time of the particular test.

### Optimum Performance

When tests are repeated under slightly different soil conditions, which are undetectable without measuring soil parameters, sharp disagreements are

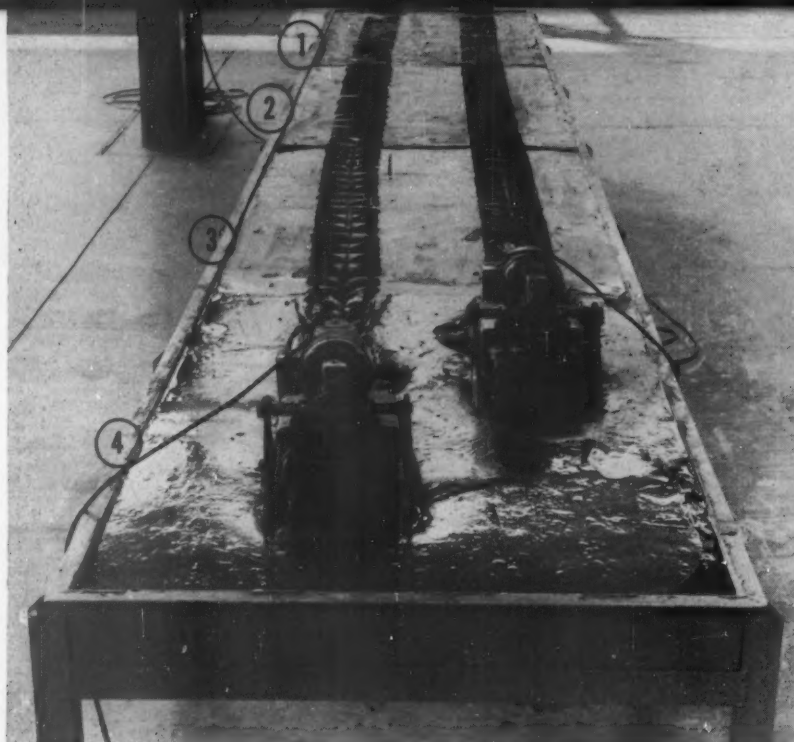


Fig. 2—Miniature proving-ground models are used to simulate exact field soil conditions.

apparent in the results. In other soil conditions, the performance merit of vehicles under consideration may either disappear or may even be reversed. These relationships are shown in Fig. 1. Since the location of a specific proving ground within the spectrum of changing soil values is seldom known, the differences in results obtained are difficult to assess and the real performance of the vehicle is uncertain.

This difficulty in defining "standard" soft-ground performance has resulted in agricultural tractor test codes which require hard-surface proving grounds. It has been shown in previous articles,<sup>2,3</sup> however, that on hard ground the ratio of drawbar pull to weight,  $P/W$ , is practically the same for all vehicles. This partially explains why most commercial tractors are alike in physical appearance.

A true picture of vehicle performance and the design differences required for optimum operation in a given environment can be obtained only if the specific proving grounds are selected to represent the complete soil spectrum. Data obtained, Fig. 1, have shown that a vehicle, which is superior in one

soil, will be equal to or even inferior to another vehicle in other soils. To cover a complete spectrum of soil changes within the given environment, four to seven soil types are usually considered necessary.

**Soil Models:** A four-soil miniature proving ground is shown in Fig. 2. The soil bin is filled with artificial soils made from mixtures of bentonite and glycol. Soil 1 is hard and strong, while soil 4 is a soupy, weak mud. The mixtures were prepared to duplicate soils with the characteristics given in Table 1.

Since all equations developed thus far<sup>1,2,3</sup> apply to both large and small vehicles, it is extremely important to have in a laboratory a soil of any desired characteristic. These equations can therefore be used both in field evaluation and in the laboratory for small scale-model evaluations. Fig. 3 shows a typical small-scale model test setup for a tracked vehicle. For this type of work, soil consistencies must be adapted to the test in a manner that permits legible deformations and loads to be produced. Reproduction of soils in the laboratory or in field tests requires that the soil be measured in nature by methods previously mentioned.<sup>1</sup>

**Predicting Performance:** From the parametric equations<sup>2,3</sup> for vehicle evaluation, a generalized method has been developed for predicting the performance of various vehicular configurations. The equations were programmed on an electronic computer to encompass not only the evaluation of wheels and tracks but also to compare, in a pre-

Table 1—Soil Values

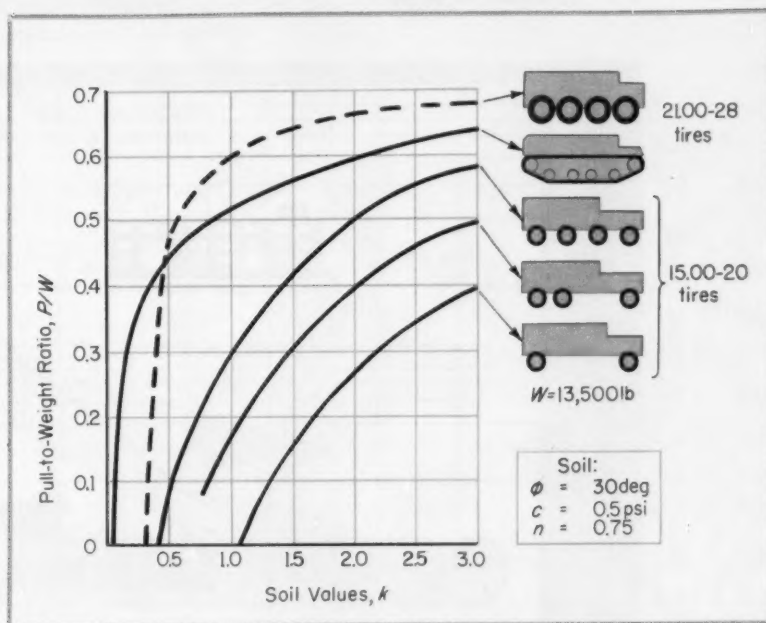
Soil Value	Soil Type			
	1	2	3	4
$k_c$	10	2	0	0
$k_\phi$	12	2.5	1	0.5
$n$	0.19	0.25	0.4	0.7
$c$	1.15	0.65	0.25	0.17
$\phi$	0	0	0	0

<sup>1</sup>References are tabulated at end of article.



Fig. 3—Characteristics such as tractive effort can be determined from scale model tests.

Fig. 4—A programmed approach to vehicle analysis yields results which can be used in predicting performance.



liminary way, complete vehicles of various structural configurations.

For instance, a change in the value of  $k$  in the computer program makes it possible to plot curves of  $P/W$  for a family of vehicles having constant weight, and four, six, or eight small-diameter wheels, tracks, or eight large-diameter tires, Fig. 4. This graph defines quantitatively the advantages of using a large number of wheels, or tracks. It also shows, however, that in this case large tires are superior to

the tracks considered only in soils with  $k \geq 0.5$ .

Such results have led to methods for mobility evaluation which produce more generalized quantitative data. In such a scheme, the mechanical mobility of vehicles in off-the-road operation is defined as an operational optimization of various mechanical performances—speed, fuel consumption, cargo-carrying capacity, pull-to-weight ratio, etc.

For example, assume that there are vehicles I, II, and III and terrains  $B_1$ ,  $B_2$ , and  $B_3$ . A terrain num-

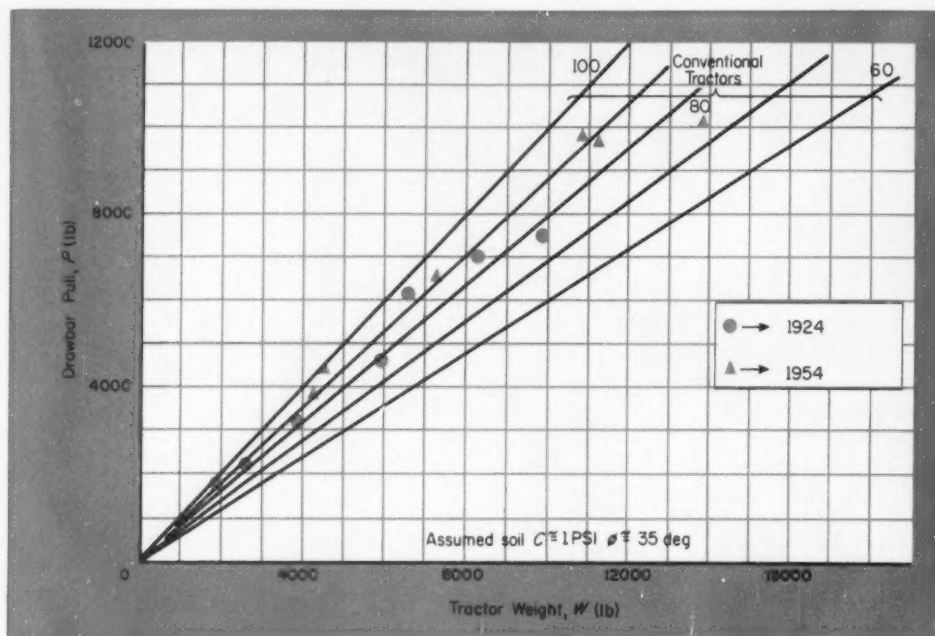


Fig. 5—Line slopes indicate that drawbar pull as a function of tractor weight has not changed significantly in 30 years.

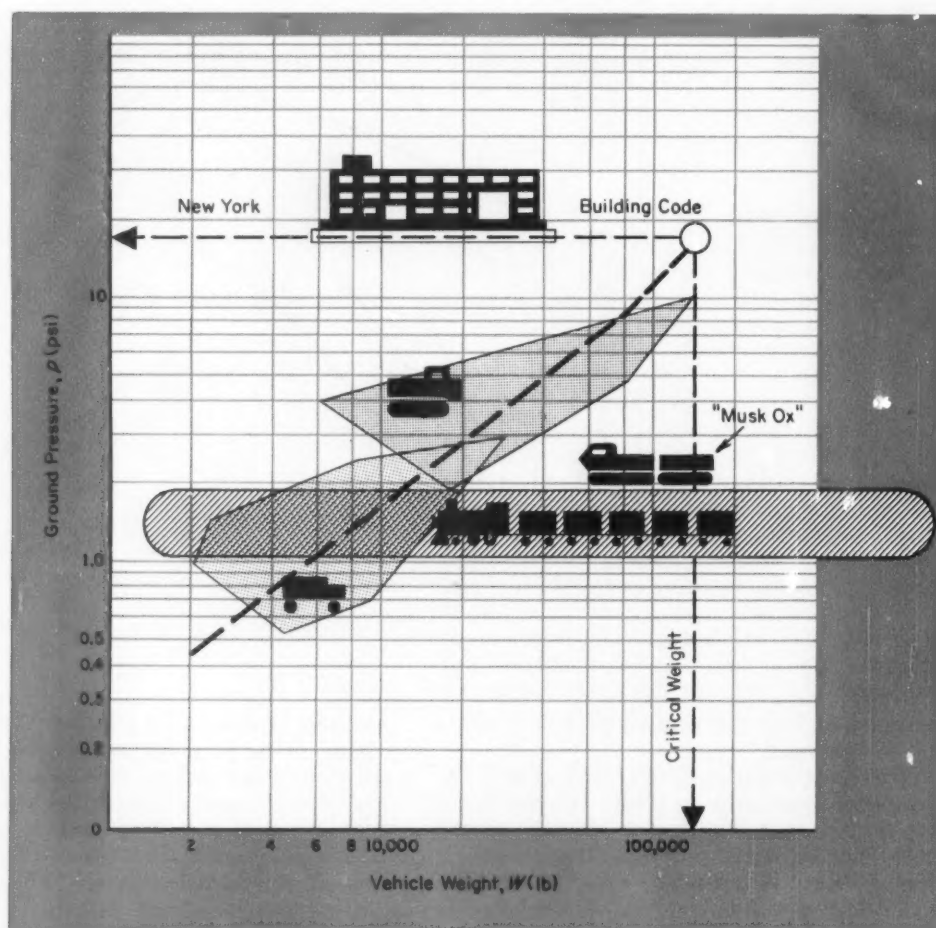


Fig. 6—Interrupted line indicates rule for variations in vehicle weights.

ber represents a typical cross section of the terrain under consideration and is selected and defined in accordance with the methods of sampling techniques and the mechanics of land locomotion.

If test data obtained at the proving grounds represent the same terrain distribution, or if theoretical analysis is applied, numbers can be established to refer to each type of performance. For instance, vehicle I may develop speeds  $(V_{B1})_I$  in terrain  $B_1$ , and  $(V_{B2})_I$  in terrain  $B_2$ , while vehicle II cruises at speeds  $(V_{B1})_{II}$ , and  $(V_{B2})_{II}$ . These values can be tabulated into a speed matrix as follows:

Vehicle	Terrain		
	$B_1$	$B_2$	$B_3$
I	$(V_{B1})_I$	$(V_{B2})_I$	$(V_{B3})_I$
II	$(V_{B1})_{II}$	$(V_{B2})_{II}$	$(V_{B3})_{II}$
III	$(V_{B1})_{III}$	$(V_{B2})_{III}$	$(V_{B3})_{III}$

In a similar way, other matrices for payload, fuel consumption, gradability, flotation, fordability, range of action, time of maintenance, and cost can be established.

All of these matrices, taken together, represent a parametric form of the definition of mechanical mobility. Furthermore, these matrices may be optimized into a single overall solution.

For example, in a simplified solution, assume that the average fuel consumption of vehicles I, II, and III in a specific terrain  $B$  are expressed by numbers shown in the following fuel economy matrix:

Vehicle	Terrain		
	$B_1$	$B_2$	$B_3$
I	6	10	15
II	10	5	8
III	7	8	10

From this tabulation it is necessary to determine which vehicles should be selected for an exclusive operation in the particular terrain to minimize the total fuel consumption in the whole area.

Assume that the distances traveled by each vehicle in each terrain,  $B_1$ ,  $B_2$ , and  $B_3$ , remain unchanged. Then the optimum characteristic will take place when the sum of specific consumptions is a minimum. If the minimum values shown in parentheses on the matrix are used, it is seen that vehicle I in terrain  $B_1$ , vehicle II in  $B_2$ , and vehicle II in  $B_3$  produce a minimum fuel consumption of 19 units. Any other selection of vehicle types would produce a greater fuel consumption up to a maximum of 35 units. Thus, only the first two types of vehicles would be selected and the third could be eliminated.

To extend this analysis, assume the following matrices for fuel consumption  $f$ ; speed  $v$ ; and payload  $p$ :

Vehicle	$f$ -matrix			$v$ -matrix			$p$ -matrix		
	— Terrain —			— Terrain —			— Terrain —		
	$B_1$	$B_2$	$B_3$	$B_1$	$B_2$	$B_3$	$B_1$	$B_2$	$B_3$
I	15	20	25	20	15	10	2	2	1
II	12	15	25	15	15	18	3	3	2
III	8	17	15	10	17	20	4	4	3

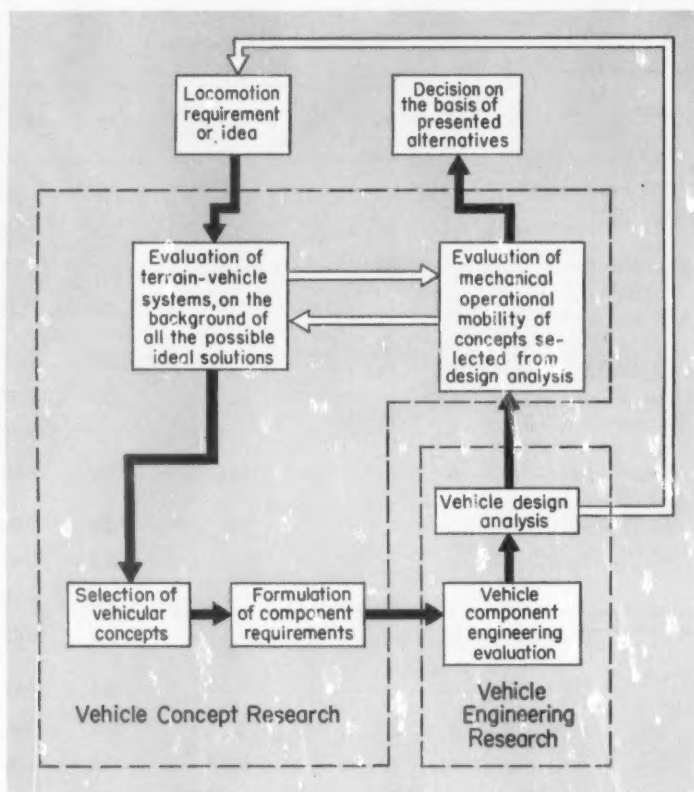
Table 2—Computations

$B_1$	$B_2$	$B_3$	$f$	$v$	$p$	$vp$	$vp/f$
I	I	I	60	13.8	1	13.8	0.23
I	I	II	60	17.4	2	34.8	0.58
I	I	III	50	18.0	2	36.0	0.72
I	II	I	55	13.8	1	13.8	0.25
I	III	I	57	14.4	1	14.4	0.25
II	I	I	57	12.9	1	12.9	0.23
III	I	I	53	11.2	1	11.2	0.21
II	II	II	52	15.1	2	30.2	0.58
II	II	I	52	12.9	1	12.9	0.25
II	II	III	42	13.5	3	40.5	0.96
II	I	II	57	15.1	2	30.2	0.53
II	III	II	54	16.6	2	32.2	0.61
I	II	II	55	17.4	2	34.8	0.63
III	II	II	48	13.5	2	27.0	0.56
III	III	III	40	14.4	3	43.2	1.08
III	III	I	50	11.6	1	11.6	0.23
III	III	II	50	14.0	2	28.0	0.56
III	I	III	43	13.8	2	27.6	0.64
III	II	III	38	13.3	3	39.9	1.05
I	III	III	47	18.9	2	37.8	0.80
II	III	III	44	17.1	3	51.3	1.16
I	II	III	45	18.0	2	36.0	0.80
II	III	I	54	18.3	1	18.3	0.25
III	II	I	48	11.2	1	11.2	0.23
III	I	II	53	13.5	2	27.0	0.50
I	III	II	57	18.2	2	36.4	0.64
II	I	III	47	16.3	2	32.6	0.69

For this example, only one of the vehicle types will be selected for each terrain, and the cargo is to be reloaded to another vehicle upon arriving at the terrain border point. This is an acceptable and economic solution if distances traveled in each ter-

rain are sufficiently large and if the unloading and reloading of the cargo may be performed quickly. The total of  $3^3 = 27$  combinations must be considered. The vehicles travel equal distances  $l$  in each terrain, and the average speeds  $v$  may be computed accordingly.

### Research: Key to the Future



Principles of vehicle mobility proposed in this series indicate that research is a must if future improvements are to be realized. This fact leads to a number of conclusions about the organization and the planning of research. First, a research department of an organization devoted to off-the-road locomotion should be concerned with two areas: 1. Research of the vehicle concept as a whole. 2. Vehicle-component engineering.

The group working in the second area should do the engineering research on materials, processes, and components to satisfy the requirements postulated by long-range locomotion

research, as well as those generated by immediate or near-future designs.

The first group, however, should be concerned with the new and broad studies in terrain-vehicle systems. This section should work on long-range projects without dealing with current requirements.

Since a study of the vehicle as a whole is more general than the component study, a certain de-emphasis of the "hardware" approach is needed, particularly in long-range planning. For the future, engineering embodiment of a new vehicle concept cannot be visualized without the prior establishment of the concept itself. This

in turn necessitates a clear-cut distinction between what may be called the design analysis and the concept analysis. Since the concept comes first, pertinent theoretical and laboratory analysis should be performed first. Only then can the designer check the feasibility of the concept from an engineering viewpoint.

Since some concepts may, and undoubtedly will, require a radical departure from conventional design practices, the matter must be evaluated by component analysis. This assures the feasibility and practicability of the theoretical idea. Furthermore standardization and a degree of compromise sometimes needed between theory and practice are promoted.

Such a study would be finalized in an overall design analysis performed by the engineering group and would lead to the counter proposals which could be re-evaluated from the viewpoint of the operational mobility. This re-evaluation would again be performed by the concept analysis group. Hence, mobility evaluation would narrow the number of acceptable choices that could be presented to top management for final decision. This process is illustrated by the *Research Flow Chart*.

It will be noted that concept evaluation is performed twice: 1. When a general terrain-vehicle system analysis is carried out. 2. After a more specific vehicle design analysis is completed. This enables the designer to select those concepts which are compatible with both ideal and practical realities. The second concept evaluation should primarily aim at the selection of the specific optimums for operational mobility. Such an activity forms an integral part of vehicle research and development. It must be located physically at the place where vehicles are born. To separate it from engineering and manufacturing would institute research programs on mobility of a very small practical value.



Fig. 7—Vehicle (Musk-OX) designed as a two car train permits high weight to be carried with minimum ground pressure. Photo, courtesy Wilson, Nuttall and Raymond Engrs. Inc.

Hence for vehicle II in terrain  $B_1$ , vehicle I in  $B_2$ , and vehicle III in  $B_3$ , the time of travel is  $t = (l/15) + (l/15) + (l/20) = 55l/300$ , and the speed  $v = 3l(300)/55l = 16.3$ . Similarly, for some of the remaining 27 combinations,

Term  $vp$  represents the payload delivery rate and  $vp/f$  is the payload delivery rate per quantity of fuel consumed. This term should be made a maximum.

In the foregoing example, it was assumed that each vehicle carried the minimum payload as restricted by the less favorable combination of terrain and vehicle type. For instance, payloads  $(p_{B1})_I$ ,  $(p_{B2})_{III}$ , and  $(p_{B3})_{III}$  amount to 2, 4, and 3 respectively. The minimum of 2 had been selected for an overall operation.

From this example, the optimum delivery of cargo per unit of time is provided by the combination of vehicles II-III-III or II-II-III ( $vp = 40.5$ ) and the most economic operation which will deliver the maximum payload per unit of fuel burned also is the combination II-II-III ( $pv/f = 0.96$ ). The best speed belongs to combinations of I-III-III, ( $v = 18.9$ ).

The final choice of the "most mobile" vehicle depends on what is more important—fuel economy, delivery rate, or speed of operation. A compromise

can be made easily when using the summary matrix and operational values other than those considered in the definition of mechanical mobility.

The examples quoted illustrate that many criteria may be chosen as an overall definition of mobility. They also illustrate those relative merits of mobility which depend on the performed optimization. In addition, they demonstrate that the meaning of these merits makes sense only within the vehicle-terrain system under consideration.

### Future Trends

An application of the analysis methods described in this series leads to a number of interesting conclusions. For instance, it has been recognized for some time that the "coefficient of adhesion" (drag/lift ratio) of all the land vehicles in general, and of tracked vehicles in particular, has not changed for the past several decades.

Fig. 5 shows the drawbar pull as a function of tractor weight as measured for the past 30 years. It is evident that the pull did not change between 1924 and 1954.

Furthermore, Fig. 6 shows that the ground pressure of vehicles is subject to an unwritten law de-

Fig. 8—Family of curves for tire-width versus tire diameters permits rapid conversion.

fined, in a first approximation, by the interrupted line. That law is implicit in the present vehicle concept. It causes the ground pressure to increase faster than vehicle weight. This is why it is easy to build a lightweight tractor with, say 2 psi, but it is impossible to do the same with a heavy tractor without departing from standard forms. All this seems to indicate that present design trends have reached the leveling off portion of the curve of progress, and no radical change should be expected if we follow the same course.

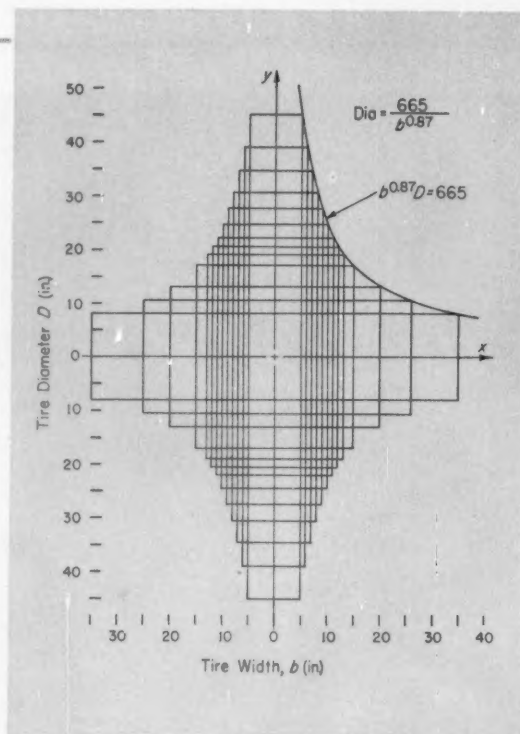
If, however, a cross-country vehicle were composed of self-propelled cars coupled together like a railroad train, then the ground pressure would be constant, and independent of total vehicle weight. This ground pressure could then be as low as that of a single small car.

This idea has been called the "train concept" and has been considered for a number of years.<sup>4</sup> One unique vehicle recently produced has a gross weight of 45 tons but exercises a ground pressure of only 2 psi. This has been made possible only through the design of the vehicle in the form of a two-car train, Fig. 7.

Other studies into the present "state of the art" have indicated quantitatively the advantages of large-diameter wheels. A study of tire forms indicates that new types of tires are needed for cross-country locomotion, and that the present trends in highway tire development tending toward lower and wider tires is incompatible with off-the-road demands. Tires having smaller width-to-diameter ratios than those presently built are more advantageous. That was demonstrated by the tires of Model T era, when cars had to operate off-highway more often than they have to today.

The resulting values from width increases and diameter increases, as far as the improvement of performance is concerned, are not the same. A family of "equivalent" tires can be computed which would produce the same  $H/W$  or  $P/W$  in a homogeneous medium. Fig. 8 shows the results of such a computation performed for a sandy loam. Wheel load  $W$  was 2500 lb and the assumed  $P/W$  ratio was 0.55. Computations show that the family of tires corresponding to these requirements has the equation  $b^{0.87}D = 665$  where  $b$  = width, and  $D$  = diameter. Thus, the designer has a strictly defined choice of equivalent wheel forms from which to select. However, such a large-diameter, narrow tire performs better than the small-diameter, wide one, if it has to operate on a deep layer of soft mud resting on hard pan. Equations and tables similar to the one cited can be developed for various soil types.

A more organized effort toward establishing land-locomotion mechanics seems inevitable in the near



future. Generally speaking, what is needed is a more rational adaptation of the form-size-load content of motor vehicles to the environment of operation. This can only be accomplished through research.

It appears that, for off-the-road locomotion, the present, purely engineering improvement of components will be paralleled sooner or later with a scientific study of the environment-vehicle relationship. The aim of this series has been to demonstrate that only such an effort can develop a more rational improvement of land locomotion.

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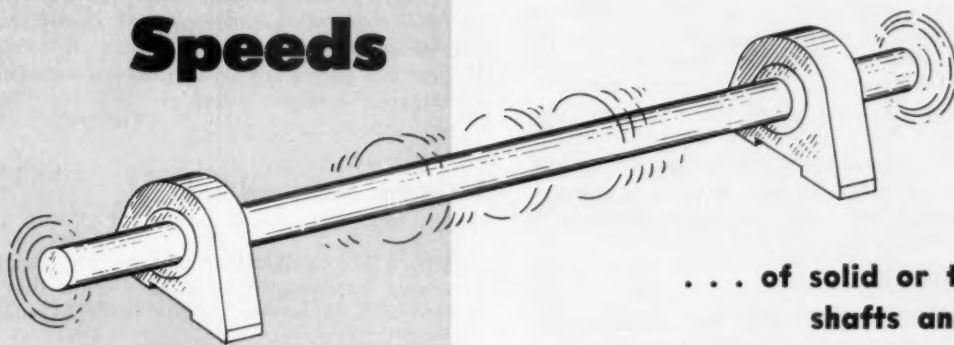
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Copies of the entire series, "Mobility of Cross-Country Vehicles," bound as a pamphlet, may be obtained for \$1.00 each from: Reader Service Dept., MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

# A simplified approach for Calculating Critical Speeds

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... of solid or tubular  
shafts and rolls

## Nomenclature

- $A$  = Cross-sectional area of roll body, sq in.
- $A_c$  = Cross-sectional area of roll covering, sq in.
- $D$  = Outside diameter of roll body, in.
- $D_s$  = Design (safe) value of outside diameter of roll body, in.
- $E$  = Modulus of elasticity of roll body, psi
- $E_c$  = Modulus of elasticity of roll covering, psi
- $g$  = Gravitational acceleration, in. per sec per sec
- $H$  = Length of hub, in.
- $I$  = Moment of inertia of roll body, in.<sup>4</sup>
- $I_c$  = Moment of inertia of roll covering, in.<sup>4</sup>
- $J$  = Length of journal, in.
- $K$  = Correction factor for hub and journal effects
- $L$  = Center distance between bearings, in.
- $N$  = Operating speed, rpm
- $N_{1/2}$  = Secondary (half) critical speed, rpm
- $N_1$  = First critical speed, rpm
- $N_2$  = Second critical speed, rpm
- $t$  = Wall thickness of roll body, in.
- $T_c$  = Thickness of roll covering, in.
- $V$  = Operating surface speed, fpm
- $V_1$  = First critical surface speed, fpm
- $V_2$  = Second critical surface speed, fpm
- $w_h$  = Mean unit weight of hub section, lb per in.
- $w_j$  = Mean unit weight of journal section, lb per in.
- $w_r$  = Mean unit weight of roll section, lb per in.
- $X$  = Tube coefficient
- $Y$  = Material coefficient
- $Y_c$  = Combined material coefficient for covered rolls
- $Z$  = Safe speed coefficient
- $\rho$  = Density of roll body, lb per cu in.
- $\rho_c$  = Density of roll covering, lb per cu in.
- $\delta$  = Maximum static deflection, in.
- $\omega_1$  = First critical speed, rad per sec

**M**ATHEMATICAL investigation of critical speeds of uniform tubular shafts and rolls indicates that wall thickness has only a minor effect on the critical-speed value. This characteristic makes it possible to simplify critical-speed calculations and is the basis of the approach presented in this article.

In practice, these calculation techniques can be applied to either solid or tubular shafts of round cross section. For new designs, suitable outside diameters which are safe with respect to critical speeds can be directly calculated after selecting an approximate ratio of wall thickness to diameter,  $t/D$ . For existing rolls and shafts where the wall thickness is not exactly known, critical speeds can be estimated with a reasonable degree of accuracy.

This method may also be used to approximate the critical speed for slender rolls and shafts with hubs and journals. Similarly, approximate values

for rolls with special outside coverings can be calculated by modifying the basic method.

### ► Uniform Shafts and Rolls

Classic expression for the first critical speed of uniform shafts or rolls supported by self-aligning bearings on rigid supports is (see Nomenclature)

$$\omega_1 = \frac{\pi^2}{L^2} \left( \frac{gEI}{A\rho} \right)^{1/2} \quad (1)$$

Fig. 1 shows the effect of the tube  $t/D$  ratio on the critical speed, expressed as the dimensionless tube coefficient,  $X$ . The equation for  $X$  from the curve is

$$X = \left[ 2 - \frac{4t}{D} + 4 \left( \frac{t}{D} \right)^2 \right]^{1/2} \quad (2)$$

Table 1 gives values for material coefficient  $Y$  which is based on the modulus of elasticity and density of the material. This coefficient is expressed by

$$Y = \left[ \frac{E}{104.2(10^6)(\rho)} \right]^{1/2} \quad (3)$$

When coefficients  $X$  and  $Y$  are introduced into Equation 1, the first critical speed becomes

$$N_1 = \frac{4,730,000 XYD}{L^2} \quad (4)$$

It is sometimes convenient to express the critical speed in terms of the roll surface speed. Hence, Equation 4 becomes

$$V_1 = \frac{1,237,000 XYD^2}{L^2} \quad (5)$$

Relationships given in Equations 1, 4, and 5 are based on several assumptions: 1. Perfectly rigid bearing supports. 2. Negligible torsional effects. 3. Frictionless self-alignment of bearings. 4. Negligible gyroscopic effects. 5. Dimensionally perfect uniform cross section.

Actual conditions seldom approach these assumptions and actual critical speeds may deviate from the calculated values by as much as 25 per cent. Therefore, it is good practice to make sure that operating speeds do not fall within the specified possible critical range. Table 2 lists recommended safe-speed ranges that are based on the calculated first critical speed. The safe-speed coefficient is related to operating speeds by  $N = ZN_1$  and  $V = ZV_1$ . Thus, selection of safe-speed coefficient  $Z$  from Table 2 insures safe operation with respect to critical speeds.

To obtain a design value for an outside diameter that is safe with respect to critical speeds,  $N_1$  in Equation 4 is replaced by  $N/Z$  and the equation is rearranged:

$$D_s = \frac{L^2 N}{4,730,000 XYZ} \quad (6)$$

If the roll surface speed is more convenient to use,  $V_1$  in Equation 5 is replaced by  $V/Z$  and the equation is rearranged:

$$D_s = \frac{L}{1,112} \left( \frac{V}{XYZ} \right)^{1/2} \quad (7)$$

For operation above the first critical speed, the rolls or shafts should pass quickly through the critical-speed zones while the equipment is being started or stopped. If this condition cannot be assured, then it is advisable to use larger diameter rolls that can be operated below the first critical speed. Ranges of variable operating speeds should not exceed safe ranges recommended in Table 2. If these safe ranges are too limited, a more accurate investigation is recommended.<sup>1</sup>

### ► Covered Shafts and Rolls

With a few modifications, the method discussed previously may be used for rolls or shafts that are covered with a special material such as rubber,

<sup>1</sup>References are tabulated at end of article.

Table 1—Typical Material Coefficients

Material	Modulus of Elasticity $E$ ( $10^6$ psi)	Density $\rho$ (lb/cu in.)	Material Coefficient $Y$
Steel	29.5	0.283	1.00
Stainless steel	28.0	0.29	0.96
Monel	26.0	0.319	0.88
Brass	16.0	0.31	0.70
Aluminum Alloys	10.3	0.10	0.99

Table 2—Recommended Safe-Speed Coefficients

Upper Limit of Operating Speed	Recommended Safe Speed Coefficient, $Z$
Half-Critical Speed*, $N_{1/2} = 0.5 N_1$	Up to 0.4*
First Critical Speed, $N_1$	From 0.6* to 0.7
Second Critical Speed, $N_2 = 4 N_1$	From 1.3** to 2.8**
Higher Critical Speeds	See Reference 1

\*The half-critical speed occurs only at horizontal shafts. The amplitude of the vibrations is usually very small unless the shaft has some distinct irregularities, as keyways, flats, or other nonuniformities in roundness.<sup>2</sup> In most cases, the first safe speed range may be taken from 0 up to 0.7  $N_1$ .

\*\*These values cannot be used for relatively flexible bearing-support conditions.

Teflon, or stone. In this case, the value for the material constant becomes

$$Y_c = Y \left[ \frac{1 + (I_c E_c / I E)}{1 + (A_c \rho_c / A \rho)} \right]^{1/2} \quad (8)$$

where  $Y$  is obtained from Equation 3 for material properties of the roll body. This new combined-material coefficient,  $Y_c$ , is used instead of  $Y$  with Equations 4 and 6. However,  $D$  and  $D_s$ , which are used with these equations, refer always to the outside diameter of the inner shell and not to the outside diameter of the covering. Hence, if the calculation must be based on the surface speed of the covered rolls, Equations 5 or 7 cannot be used directly, but must be modified in form. Accordingly, Equation 5 becomes

$$V_1 = 1,237,000 X Y_c \frac{D^2}{L^2} \left( 1 + \frac{2T_c}{D} \right) \quad (9)$$

and Equation 7 becomes

$$D_s = \frac{L}{1,112} \left[ \frac{V}{X Y_c Z \left( 1 + \frac{2T_c}{D} \right)} \right]^{1/2} \quad (10)$$

Equations 8 and 10 indicate that the design of covered rolls is strictly on a trial-and-error basis. The recommended design procedure is to neglect the effect of the covering at the first step, and to calculate an approximate diameter by using the empirical formula,

$$D_s = \frac{L}{1,000} \left( \frac{V}{X Y Z} \right)^{1/2} - T_c \quad (11)$$

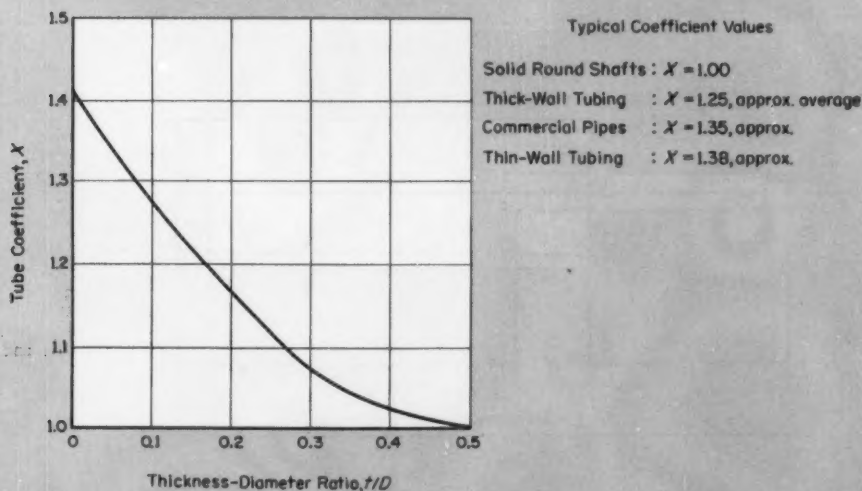
This diameter can be used with Equations 8 and 10 to obtain a more accurate value. This procedure is then repeated until sufficient accuracy has been obtained.

## ► Rolls or Shafts with Hubs and Journals

Critical speeds or safe-design diameters for rolls and shafts consisting of a uniform roll body with hubs and journals, Fig. 2, can be approximately estimated by using the same method as described in the two preceding sections. In this case, the effects of hubs and journals are neglected and the roll is considered as entirely uniform. The cross-sectional dimensions and the material of the roll body determine the basic values to be used with the preceding equations. The value  $L$  is still the center distance between bearings, since it would be incorrect to consider  $L$  as the width of the roll face. The introduced error will be small if the journals are relatively short and stiff with respect to the roll body. In all practical cases, the exact theoretical values of the critical speeds will be somewhat below the estimated values. The same applies for rolls and shafts that extend more than a short distance beyond the bearings.

In questionable situations, where the journals are relatively long or thin, or if the hubs are relatively heavy, the effect of hubs and journals can be corrected within certain limits by using a correction quotient  $K$  which can be found by interpolating the

Fig. 1—Tube coefficients used for determining effect of wall thickness and diameter on critical speeds.



typical values given in Table 3. This correction quotient depends on the ratios of certain properties of hubs and journals to corresponding properties of the roll body. With reference to Fig. 2, let

$(EI)_h$  = Sum of all  $EI$  values for the various materials and cross-sections within hub length  $H$ . Mean  $EI$  values should be used for members of varying cross section.

$(EI)_j$  = Mean  $EI$  value for journal section  $J$ .

$(EI)_r$  =  $EI$  value for roll-body section  $R$ . Sum of  $EI$  values should be used for covered rolls.

Then, the 6 ratio values which determine  $K$  are:

$$J/L, (EI)_j/(EI)_r, w_j/w_r,$$

$$H/L, (EI)_h/(EI)_r, w_h/w_r,$$

Correction quotient  $K$  may be approximated from Table 3 by finding the constants that best match the 6 given ratio values and interpolating between these values by inspection. A more accurate analytical method for determining  $K$  by interpolation is outlined in Example 2.

Hence, to correct for the effect of hubs and journals, results of Equations 4, 5, and 9 should be divided by  $K$ .

For extreme situations, reliable interpolation of the value of  $K$  from Table 3 may become difficult or impossible. In these cases, more accurate values may be found by using Stodola's methods,<sup>2</sup> Holzer's method,<sup>2,3</sup> or the energy method.<sup>4</sup> For uniform shafts, the widely used approximate equation,  $N_1 = 187.7/(8\%)$ , gives a value that is 11.2 per cent below the theoretical critical speed.

Practical application and possibilities of this method of critical-speed calculation are demonstrated by the examples.

## Examples

**Example 1:** The input shafts of two worm gear-driven power screws are to be connected by a 180-in. long horizontal cross-shaft. Determine the size shaft which is required for safe operation if  $N = 300$  rpm. The shaft must be made from commercial seamless steel pipe. From Fig. 1,  $X = 1.35$ ; from Table 1,  $Y = 1.00$ ; and from Table 2,  $Z = 0.4$ . Hence, the required outside diameter is, from Equation 6,

$$D_s = \frac{180^2(30)}{4,730,000(1.35)(1)(0.4)} = 3.80 \text{ in.}$$

The next larger commercial pipe size is 4.00-in. outside diameter, or 3½-in. nominal pipe size. The wall thickness for a standard 3½-in. pipe is  $t = 0.226$  in. The corresponding  $t/D$  ratio is  $0.226/4 = 0.0565$ . The actual tube coefficient from Fig. 1 is  $X = 1.337$  which compares to the 1.35, approximate value. Thus, a 3½-in. standard pipe will be safe with respect to critical speeds.

**Example 2:** A balanced thin-wall brass roll, 6.500-in. OD by 0.1875-in. wall, has a face width of 100 in. and a bearing center distance of 130 in. It is provided with two 1.938-in. diam stainless-steel journals in 3 in. long solid cast-iron hubs. What is the value of the calculated critical speed?

For the brass roll,  $\rho_r = 0.316$  lb per cu in. and  $E_r = 17 \times 10^6$  psi; for the cast-iron hub,  $\rho_h = 0.26$  lb per cu in. and  $E_h = 16 \times 10^6$  psi; and for the stainless-steel journal,  $\rho_j = 0.29$  lb per cu in. and  $E_j = 29 \times 10^6$  psi.

To make use of Fig. 1,  $t/D = 0.1875/6.5 =$

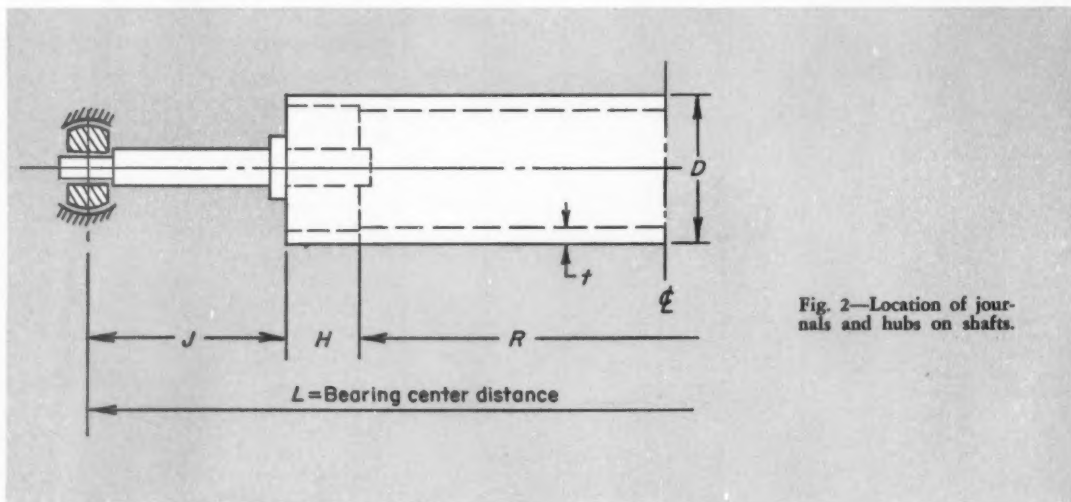


Table 3—Correction Quotient  $K$  for Effect of Hubs and Journals

$J/L$	$(EI)_j/(EI)_r$	$w_j/w_r$	$H/L \rightarrow \begin{matrix} 0 & 0.025 & 0.100 \\ w_h/w_r \rightarrow \begin{matrix} -2- & -10- & -2- & -10- & -2- & -10- \\ (EI)_h/(EI)_r \rightarrow \begin{matrix} 10 & 2 & 10 & 2 & 10 & 2 & 10 & 2 & 10 & 2 \end{matrix} \end{matrix} \end{matrix}$											
0	1	0	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.19	1.19
		0.5	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.19	1.19
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.19	1.19
	0.1	0	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.19	1.19
		0.5	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.19	1.19
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.02	1.02	1.19	1.19
0.05	1	0	0.99	0.99	0.99	0.99	1.00	1.00	1.06	1.06	1.02	1.03	1.32	1.34
		0.5	1.00	1.00	1.00	1.00	1.00	1.00	1.06	1.06	1.03	1.03	1.33	1.34
		4	1.02	1.02	1.02	1.02	1.02	1.02	1.08	1.08	1.04	1.05	1.34	1.36
	0.1	0	1.00	1.00	1.00	1.00	1.01	0.99	1.07	1.07	1.03	1.04	1.34	1.35
		0.5	1.00	1.00	1.00	1.00	1.01	1.01	1.07	1.07	1.03	1.04	1.34	1.35
		4	1.03	1.03	1.03	1.03	1.03	1.03	1.09	1.09	1.05	1.06	1.36	1.37
0.10	1	0	0.98	0.98	0.98	0.98	0.99	0.99	1.09	1.09	1.01	1.02	1.42	1.45
		0.5	0.99	0.99	0.99	0.99	1.00	1.00	1.10	1.10	1.02	1.04	1.43	1.46
		4	1.07	1.07	1.07	1.07	1.08	1.08	1.17	1.17	1.09	1.11	1.48	1.51
	0.1	0	1.02	1.02	1.02	1.02	1.03	1.04	1.15	1.14	1.06	1.08	1.52	1.55
		0.5	1.04	1.04	1.04	1.04	1.05	1.05	1.16	1.17	1.08	1.09	1.53	1.56
		4	1.14	1.14	1.14	1.14	1.15	1.15	1.25	1.26	1.17	1.18	1.59	1.62
0.15	1	0	0.95	0.95	0.95	0.95	0.96	0.96	1.10	1.10	0.98	1.00	1.48	1.53
		0.5	0.98	0.98	0.98	0.98	0.98	0.99	1.12	1.13	1.00	1.03	1.50	1.55
		4	1.15	1.15	1.15	1.15	1.16	1.16	1.28	1.28	1.15	1.19	1.60	1.66
	0.1	0	1.08	1.08	1.08	1.08	1.10	1.10	1.29	1.29	1.14	1.17	1.78	1.82
		0.5	1.12	1.12	1.12	1.12	1.14	1.14	1.32	1.33	1.18	1.20	1.80	1.84
		4	1.37	1.37	1.37	1.37	1.38	1.39	1.54	1.54	1.40	1.43	1.96	2.00

Table 4—Interpolation of Correction Quotient  $K$  for Example 2

Item	$H/L$	$w_h/w_r$	$(EI)_h/(EI)_r$	$J/L$	$(EI)_j/(EI)_r$	$w_j/w_r$
<b>Initial Tabulation</b>						
$Q_1$ (Actual ratio value)	0.0231	7.58	4.52	0.1153	0.0636	0.727
$Q_2$ (Nearest ratio value in Table 3)	0.0250	10	2	0.10	0.10	0.5
$Q_3$ (Next nearest ratio value in Table 3)	0	2	10	0.15	1.00	4.0
$Q_4 = Q_2 - Q_3$	+0.025	+8	-8	-0.05	-0.90	-3.5
$Q_5 = Q_2 - Q_1$	+0.0019	+2.42	-2.52	-0.0153	+0.0364	-0.227
$Q_6 = Q_5/Q_4$	+0.076	+0.303	+0.315	+0.306	-0.0405	+0.0648
<b>Final Tabulation</b>						
$K_0$	1.17	1.17	1.17	1.17	1.17	1.17
$K_1$	1.04	1.05	1.16	1.33	1.10	1.26
$Q_7 = K_1 - K_0$	-0.13	-0.12	-0.01	+0.16	-0.07	+0.09
$Q_8 = Q_6 Q_7$	-0.0099	-0.0364	-0.0032	+0.0490	+0.0028	+0.0058

0.0288. Hence, from Fig. 1,  $X = 1.374$ . The material coefficient is determined from Equation 3:

$$Y = \left[ \frac{17(10^6)}{104.2(10^6)(0.316)} \right]^{1/4} = 0.718$$

Hence, from Equation 5, the approximate critical speed, neglecting the hubs and journals, is

$$V_1 = \frac{1,237,000(1.374)(0.718)(6.5)^2}{130^2} = 3050 \text{ fpm}$$

To correct this value for the effect of hubs and journals with the correction quotient  $K$ , the following quantities must be determined:  $J = (130 - 100)/2 = 15 \text{ in.}$ ,  $w_r = A_r \rho_r = 3.72(0.316) = 1.176 \text{ lb per in.}$ ,  $w_j = A_j \rho_j = 2.95(0.29) = 0.855 \text{ lb per in.}$  Weight of the cast-iron hub is  $26.5(0.26) = 6.88 \text{ lb per in.}$  Unit weight of entire hub section is  $w_h = 6.88 + 0.855 + 1.176 = 8.91 \text{ lb per in.}$  Moment of inertia values for the roll body, journal, and cast-iron hub are  $18.59 \text{ in.}^4$ ,  $0.692 \text{ in.}^4$ , and  $68.4 \text{ in.}^4$ , respectively. Corresponding stiffness values are:  $(EI)_r = 17(10^6)(18.59) = 316 \times 10^6 \text{ lb-in.}^2$ ,  $(EI)_j = 29(10^6)(0.692) = 20.1 \times 10^6 \text{ lb-in.}^2$ , and  $(EI)_h = [316 + 20.1 + 16(68.4)] 10^6 = 1430 \times 10^6 \text{ lb-in.}^2$ .

The six ratio values used to find correction quotient  $K$  are tabulated as the  $Q_1$  values in Table 4 which represents the recommended method of interpolating values from Table 3.

From Table 3, the correction quotient corresponding to the  $Q_2$  values in Table 4 is  $K_0 = 1.17$ . Also, the correction coefficients,  $K_1$ , which correspond to the combination of one  $Q_3$  value and the remaining  $Q_2$  values, are listed on line 7 of Table 4. These  $K_1$  values appear in the column corresponding to the  $Q_3$  value used. Thus,  $K_1 = 1.04$  corresponds to the combination of ratio values,  $H/L = 0$ ,  $w_h/w_r = 10$ ,  $(EI)_h/(EI)_r = 2$ ,  $J/L = 0.10$ ,  $(EI)_j/(EI)_r = 0.10$ , and  $w_j/w_r = 0.5$ .

The interpolated correction quotient  $K$  can now be calculated from Table 4 using the relationship,

$$K = K_0 + \Sigma Q_8 = 1.17 + 0.0081 = 1.18 \text{ (approx)}$$

Hence, the corrected critical speed value is  $N_1 = 3050/1.18 = 2580 \text{ fpm}$ . The energy method<sup>4</sup> gives a calculated critical speed value of  $2540 \text{ fpm}$ . Thus, the error in the approximate value is  $100(3050 - 2540)/2540 = 19.7 \text{ per cent}$ . For the corrected value, this error becomes  $1.6 \text{ per cent}$ .

Errors as great as  $5 \text{ per cent}$  can be expected by this method. However, in this example, the journals that were chosen are very slender with respect to common practice. For most applications, the effect of the journals on the critical speed is so small that  $K$  approaches unity and may be neglected.

**Example 3:** A rubber-covered roll must be designed for a maximum surface speed of  $2500 \text{ fpm}$ . The roll shall have a face width of  $240 \text{ in.}$  and the bearing center distance is  $260 \text{ in.}$  The rubber covering shall be  $1/4\text{-in.}$  thick, weighing  $0.045 \text{ lb/in.}^3$  and having a modulus of elasticity of  $5000 \text{ psi}$ . What is the required outside diameter of the thin-wall steel tubing that shall be used as the basic roll body?

From Fig. 1 and Tables 1 and 2:  $X = 1.38$  approx,  $Y = 1.0$ , and  $Z = 0.70$  max. Hence, from Equation 11,

$$D_s \approx \frac{260}{1000} \left[ \frac{2500}{1.38(1.0)(0.70)} \right]^{1/4} - 0.25 = 12.98 \text{ in.}$$

If this steel tube is to have a  $1/4\text{-in.}$  wall, the actual  $t/D$  ratio will be  $0.25/13 = 0.0192$ . Again, from Fig. 1,  $X = 1.388$ . Also, for the  $13.5\text{-in.}$  OD by  $1/4\text{-in.}$  wall covering,  $I_c = 228 \text{ in.}^4$  and  $A_c = 10.4 \text{ sq in.}$  Similarly, for the  $13 \text{ in.}$  OD by  $1/4\text{-in.}$  wall steel tube,  $I = 204 \text{ in.}^4$  and  $A = 10.0 \text{ in.}^2$ . Therefore, from Equation 8:

$$Y_c = 1.0 \left[ \frac{1 + (228)(5000)/204(29.5)(10^6)}{(1 + (10.4)(0.045)/10(0.283))} \right]^{1/4} = 0.926$$

When this correction factor is used in Equation 10,

$$D_s = \frac{260}{1,112} \left[ \frac{2500}{1.388(0.926)(0.7) \left( 1 + \frac{0.50}{13} \right)} \right] = 12.1 \text{ in.}$$

Recalculating a new  $Y_c$  value and using the  $D_s$  value of  $12.1 \text{ in.}$  in a new equation for  $D_s$  gives the same result of  $D_s = 12.1 \text{ in.}$

If the journals used with this roll are reasonably stiff the outside diameter of this roll should be not less than  $12.1 + (2 \times 0.25) = 12.6 \text{ in.}$

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## They Say . . .

"Fifteen years ago a typical airplane design required 15 engineering man-hours per airplane pound. Today it approximates 100. Another organization in production facilities could be designed and constructing production facilities, measures the same phenomenon by saying that ten years ago \$150,000 in production facilities could be designed and constructed per engineering man-year; only \$80,000 worth today."—NORMAN J. REAM, *director of systems planning, Lockheed Aircraft Corp., Burbank, Calif.*

*Nomograms simplify preliminary  
design calculations for*

# Cooling By Evaporation

*with expendable liquid systems*

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**E**XPENDABLE-LIQUID cooling systems provide an efficient method for removing heat from equipment subject to short-duration temperature rises. In such systems, which have been used to advantage in certain missile applications, cooling is accomplished by simply permitting the coolant to boil away.

## Nomenclature

$C_p$  = Specific heat of the liquid, Btu per lb per deg F  
 $L$  = Latent heat of vaporization, Btu per lb  
 $Q_i$  = Rate of heat input to liquid, Btu per min  
 $Q_r$  = Heat required to raise temperature of liquid, Btu  
 $T_h$  = Time required to heat liquid to boiling temperature, min  
 $T_v$  = Time required to vaporize liquid at boiling temperature, min  
 $t_a$  = Ambient temperature of liquid before heating, F  
 $t_{bp}$  = Boiling temperature of liquid, F  
 $\Delta t$  = Temperature rise, deg F  
 $= t_{bp} - t_a$   
 $W$  = Weight of liquid, lb

To estimate the amount of liquid solution required for a specific system, two conditions of heat transfer must be analyzed: 1. Heating the liquid. 2. Vaporizing the liquid. This article presents two nomograms to speed and simplify the necessary calculations.

**Nomogram Solution:** The first nomogram, Fig. 1, permits direct determination of the time required to heat 1 lb of a liquid solution to its boiling temperature. It solves the relationships (see Nomenclature),

$$Q_r = WC_p \Delta t$$

$$T_h = \frac{Q_r}{Q_i}$$

where  $W = 1$  lb. For other solution weights, time  $T_h$  can be found by direct proportion.

**EXAMPLE:** Normal temperature of a piece of electronic equipment is  $t_a = 26$  F. In the operation of this equipment, a heat input of  $Q_i = 50$  Btu per min is developed. Find the time required to reach the boiling point of the liquid solution.

Liquid capacity of the system,  $W = 1$  lb. The liquid solution is a mixture containing, by weight,  $37\frac{1}{2}$  per cent

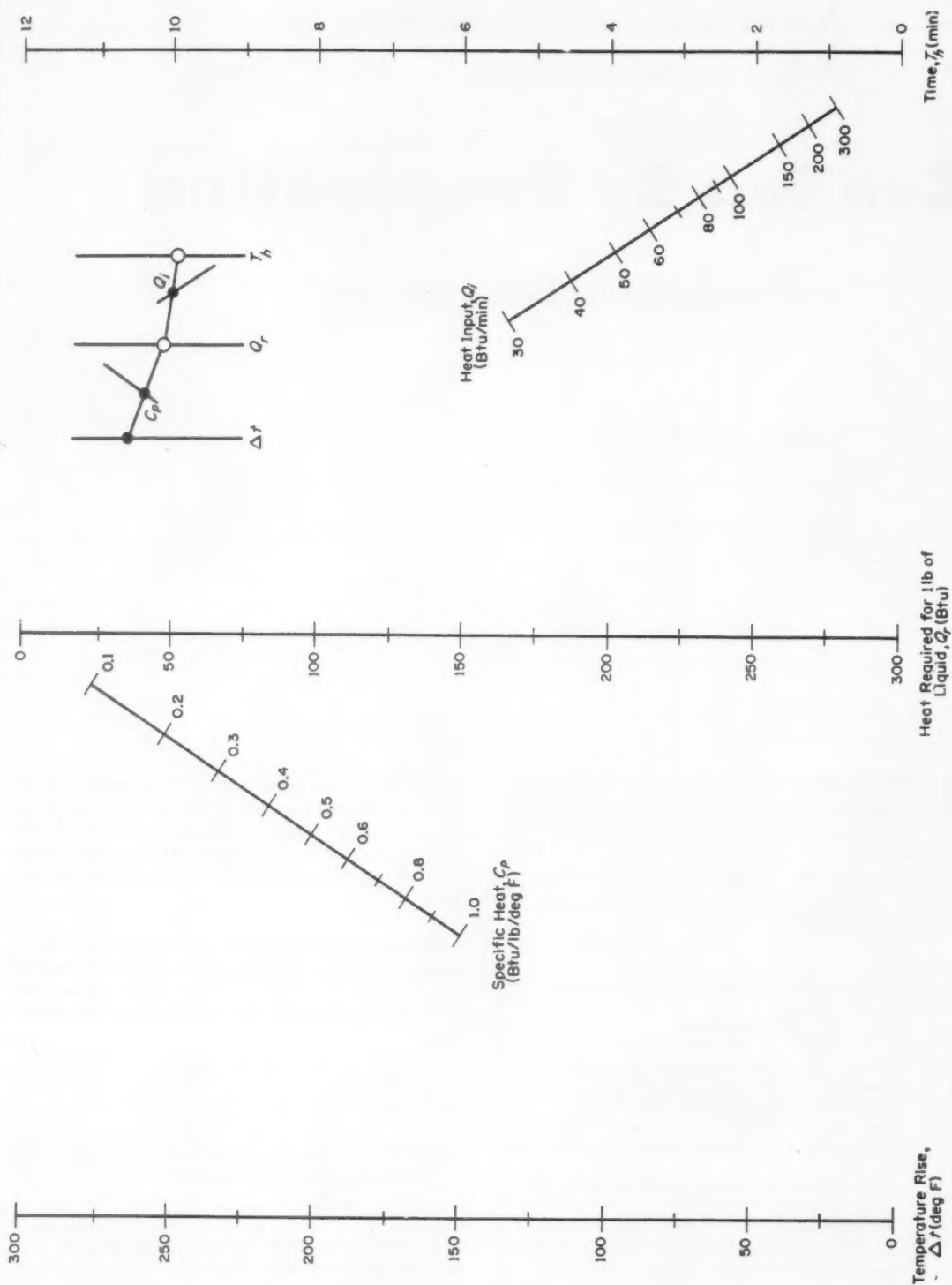


Fig. 1—Time required to raise the temperature of 1 lb of liquid solution at sea-level atmosphere.

water and 62½ per cent ethylene glycol. Boiling point of this solution at sea-level pressure conditions is  $t_{bp} = 226$  F and the specific heat is  $C_p = 0.845$  Btu per lb per deg F. These values can be found from standard tables.

On the nomogram in Fig. 1, connect  $\Delta t = 200$  F with  $C_p = 0.845$  by a straight line. Read  $Q_r = 169$  Btu. Connect  $Q_r$  with  $Q_i = 50$  Btu by a straight line. Find  $T_h = 3.38$  min. The nomogram can be worked from either or both sides as long as  $Q_r$  forms a common point.

The second nomogram, Fig. 2, permits direct determination of the time required to vaporize a given amount of liquid solution. It solves the relationship,

$$T_v = \frac{WL}{Q_i}$$

This nomogram is based on a heat input of 1 kw which is equivalent to 56.868 Btu per min. Values for other heat inputs may be increased or decreased in direct proportion.

EXAMPLE: A piece of equipment has a heat input of 2 kw in a 10-minute period. If the coolant used is the same as in the previous example, find the amount of liquid required to remove this heat load. From standard tables, the latent heat of vaporization of this solution at sea-level atmospheric conditions is  $L = 358$  Btu per lb. On the nomogram in Fig. 2, connect  $L = 358$  Btu per lb to  $T = 10$  min by a straight line. Read  $W = 1.58$  lb, which is the weight of liquid required for 1 kw of heat input. For the system considered here, then,  $W = 2(1.58) = 3.16$  lb.

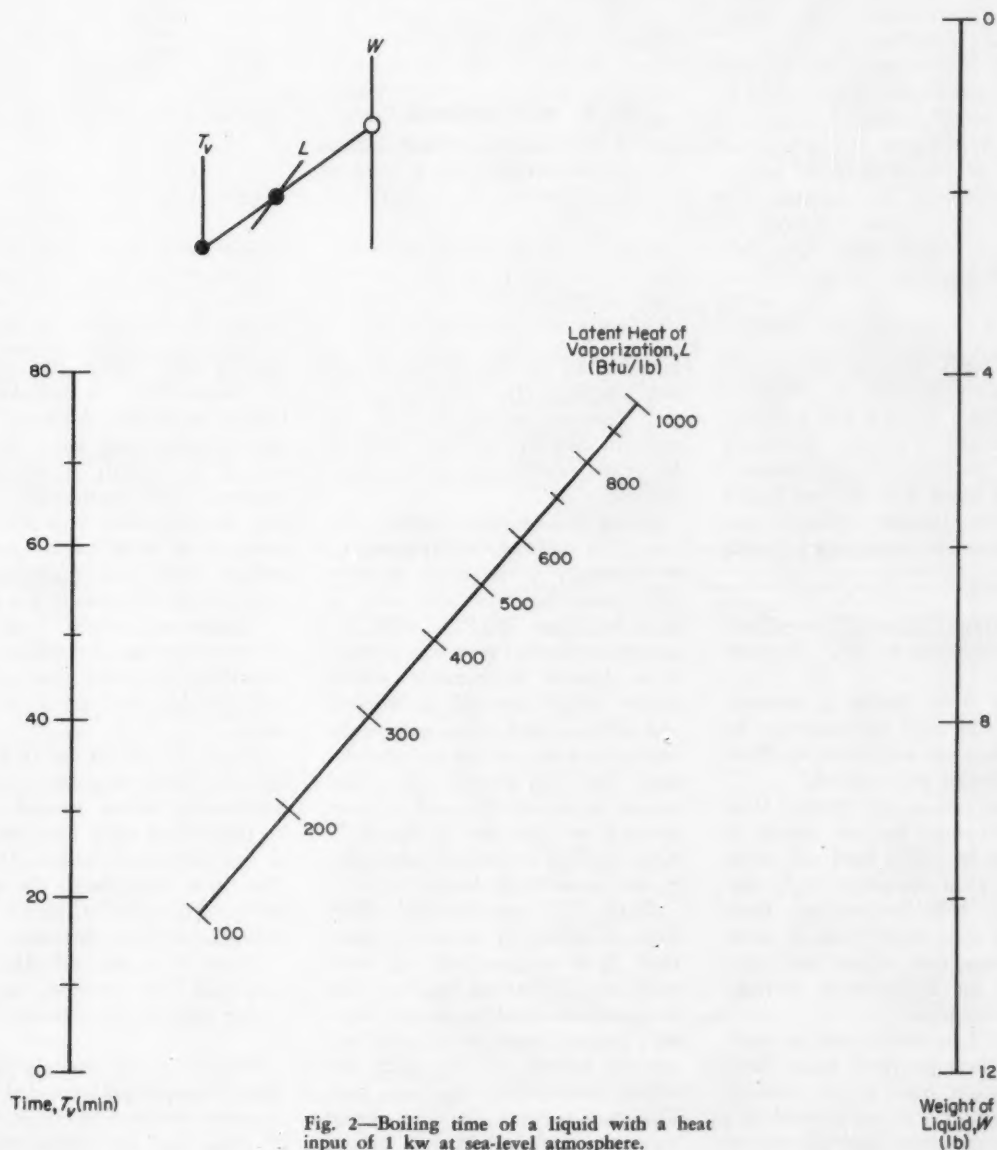


Fig. 2—Boiling time of a liquid with a heat input of 1 kw at sea-level atmosphere.

*Strength and assembly  
considerations in . . .*

# Selecting Fastener Materials

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Chicago, Ill.

**F**ASTENER materials offer a wide latitude of choice in design to meet specific strength and assembly requirements. Physical standards for the most widely used fastener materials along with the key factors that affect fastener strength and performance are summarized in this article.

**Steel:** Eight material grades have been established by SAE for steel fasteners:

**GRADE 0** is merely a reference that can be used on drawings for bolts where no particular mechanical properties are required.

**GRADE 1** is a low carbon steel. The part may be hot forged. It may also be cold forged and stress relieved at a relatively high temperature. High-temperature stress relief of cold-forged bolts is usual when large cold upsets are made, such as for square-head, carriage, and similar bolts.

**GRADE 2** is widely used for cold-headed, hexagon-head bolts. Since the hexagon head is not severely cold upset, it is stress relieved at a lower temperature that will prevent

head failure but not completely anneal the bolt. The resulting product, therefore, retains much of the strength benefit of cold working. In certain cases it may not be stress-relieved.

**GRADE 3** is a medium-carbon steel bolt. It is cold worked by heading, by extrusion of the blank, and by roll threading. This bolt may be aged at about 700 F to meet required mechanical properties. It may have special applications where higher fatigue strength is required and where a high stress cycle in the bolt cannot be avoided by joint design. The bolt, however, has limitations as to ductility and ultimate strength as compared to Grade 5. Also, it offers no fatigue advantage in the usual joint design.

**GRADE 5** is recommended where high preloading of the bolt is practical. It is a quenched and tempered medium-carbon steel bolt, and is most economical where the highest clamping force per dollar of bolt cost is desired. ASTM A325 describes substantially the same bolt. The requirements for this grade may be upgraded in the future,

thereby eliminating the necessity for Grade 6 bolts. In that event, the higher properties of Grade 5 will also compete with alloy Grades 7 and 8, particularly in smaller diameters, with considerable saving over the high-alloy bolt cost.

**GRADE 6** is a special medium-carbon steel bolt, quenched and tempered, which usually has a higher manganese content. It is useful where properties somewhat higher than those of Grade 5 are required, without the expense of an alloy steel.

**GRADE 7** is an alloy steel, quenched and tempered. It is used particularly where threads are to be cold rolled after heat treatment to get improved fatigue strength. This bolt has about the highest hardness suitable for normal thread rolling after heat treatment.

**GRADE 8** is also an alloy steel, quenched and tempered, but is of higher strength than Grade 7.

**Plastic:** Typical strength data for recently developed threaded plastic fasteners are listed in Table 1. Most of these data are representative of

fasteners made from Zytel 101. Other plastic materials being used for fasteners are PVC, Teflon, and Nylatron G.

Plastic fasteners usually must meet one or more of five conditions: 1. Corrosion resistance. 2. Color match. 3. Sealing. 4. Unavoidable

**Table 1—Strength of Representative Plastic Fasteners**

Size-Tpi	Minor Diam (in.)	Stress Area (sq in.)	Ultimate Torque (in.-lb)
2-56	0.064	0.0036	0.44
4-40	0.081	0.0060	1.19
6-32	0.0997	0.0090	2.14
8-32	0.1257	0.0139	4.3
10-24	0.1389	0.0174	6.61
10-32	0.1517	0.0199	8.2
¼-20	0.1887	0.0317	16.00
¼-28	0.2062	0.0362	20.83
⅜-18	0.243	0.0522	34.90

Note: In assembly, torque values of 70 to 80 per cent of the ultimate torques should be used.

contact with painted or porcelain surfaces. 5. Insulation.

On the other hand, some plastic fasteners have definite limitations and are not suitable for use where temperatures exceed 350 F, where high stress or shear requirements exist, and where cost per piece is critical.

**Nonferrous Metals:** For fasteners made of nonferrous metals, yield

**Table 2—Recommended Torque for Hex-Head Nonferrous Bolts**

	Yellow Brass	Naval Brass	Mixed Metal	Low Silicon Bronze	2024-T4 Aluminum	304 Stainless
Tensile (psi)	75,000	58,000	80,000	80,000	80,000	85,000
Yield (psi)	30,000	25,000	30,000	35,000	24,000	28,000
Size-Tpi	Recommended Torque (lb-in.)					
¼-20	40	35	70	70	50	50
⅜-18	100	80	150	150	120	120
½-16	150	140	200	200	190	190
Size-Tpi	Recommended Torque (lb-ft)					
¼-13	30	25	50	50	40	40
½-11	65	50	100	80	80	75

Note: Use values above only as a guide. Variations in alloys, contacting surfaces, and lubrication of threads affect torque values. Verify torque to be used by actual torque test.

and tensile strengths may vary widely, Table 2, depending upon the extent of cold working of raw materials and subsequent cold working during fastener production operations.

Where the bolt and nut are each made of dissimilar materials, torque values frequently become erratic. In nonferrous metals, this is particularly important for they often tend to seize and gall more readily, if dissimilar.

**Extreme-Temperature Service:** Strength data in Table 3 relate to fasteners and parts subjected to high or low temperature. Note that all of the highest temperature alloys are stainless steels.

In general, bolting for elevated-temperature service should be selected so that its allowable stress at working temperatures is not less

than that of the material it is fastening together. At operating temperatures around 1100 F, fastener material should be similar, if not identical, to the parts being fastened. Parts made from austenitic alloys should, preferably, be joined with ASTM Grade A320 fasteners in high-temperature service.

Another important factor in both high and low-temperature service is that fasteners should be selected with strengths not materially greater than the part being fastened. This will avoid breakage of the parts which the fasteners hold together.

Differential expansion must be considered in bolting of flanges of austenitic material. Such flanges are usually selected for their resistance to oxidation and certain corrosive actions. However, such materials have low yield strength properties

**Table 3—Properties of Fastener Materials<sup>1</sup> for Extreme-Temperature Service**

ASTM Designation			Physical Properties							
Spec No.	Grades	Diameter Range (in.)	Temperature Limit (F)	Tensile Strength (1000 psi)	Yield Strength (1000 psi)	Minimum Elongation In 2 In. (per cent)	Minimum Reduction Of Area (per cent)	Impact Strength (ft-lb)	Brinell Hardness	Rockwell Hardness
A307	B	¼ to 2½	450	90 max	70 max	15	45		104-187	B64-92
A261	BO	2 and under	850	100 min	75 min	16	45		200-260	C15-26
A354	BB	2½ and under	750	105 min	83 min	20	50		217-285	C18-30
A354	BC	2½ and under	750	125 min	109 min	16	50		255-321	C25-34
A354	BD	1½ and under	750	150 min	125 min	14	35		302-352	C32-38
A193	B7	2½ and under	1000	125 min	105 min	16	50		255-321	C25-34
A193	B7A, B14, B16	2½ and under	1100 <sup>2</sup>	125 min	105 min	18	50		255-321	C25-34
A193	B5	2½ and under	1100 <sup>3</sup>	100 min	85 min	17	55		217-285	C18-30
A193	B8, B8C, B8T	All diam	1500 <sup>4</sup>	75 min	30 min	35	50		—	—
A193	B8, B8C, B8T	¾ and under	1500 <sup>4</sup>	125 min	100 min	12	35		320 max	C34 max
A193	B8, B8C, B8T	¾ thru 1	1500 <sup>4</sup>	115 min	90 min	15	35		320 max	C34 max
A193	B8, B8C, B8T	over 1; to 1½	1500 <sup>4</sup>	105 min	65 min	20	35		320 max	C34 max
A193	B8, B8C, B8T	over 1½; to 1½	1500 <sup>4</sup>	100 min	50 min	28	45		320 max	C34 max
Service Below —20 F										
A320	L7	2½ and under	—150	125 min	105 min	16	50	15	255-321	C25-34
A320	L10	4 and under	—150	70 min	40 min	25	40	15	—	—
A320	L43	4 and under	—150	125 min	105 min	16	50	15	255-321	C25-34
A320	L9	2½ and under	—225	125 min	105 min	16	50	15	255-321	C25-34
A320	B8F	Same as for A193 Grades B8	—300	Same physical properties as for A193 Grades B8 <sup>4</sup>				15	—	—

<sup>1</sup>All materials are ferritic steels except where noted.

<sup>2</sup>Grades B14 and B16 have greater strength than B7A at temperatures between 850 F to 1050 F.

<sup>3</sup>Used usually to provide greater resistance to oxidation and corrosion.

<sup>4</sup>Austenitic stainless steel. Carbide solution treated (annealed).

<sup>5</sup>Austenitic stainless steel. Cold drawn to surface BHN of 320 max (strain hardened).

<sup>6</sup>Austenitic stainless. Lowest physicals, annealed. All others cold drawn.

Table 4—Torque and Tensile Requirements for Steel Fasteners

Screw Size	Machine Screws		Bolts and Cap Screws							
	1010 Steel*		SAE Grade 1†		SAE Grade 2‡		SAE Grade 3§		SAE Grade 5**	
	Torque (lb-in.)	Breaking Load (lb)	Torque (lb-in.)	Breaking Load (lb)	Torque (lb-in.)	Breaking Load (lb)	Torque (lb-in.)	Breaking Load (lb)	Torque (lb-in.)	Breaking Load (lb)
2-56	3.8	242	....	....	....	....	....	....	....	....
2-64	4.5	262	....	....	....	....	....	....	....	....
3-48	5.0	322	....	....	....	....	....	....	....	....
3-56	5.7	350	....	....	....	....	....	....	....	....
4-36	5.7	370	....	....	....	....	....	....	....	....
4-40	7.5	403	....	....	....	....	....	....	....	....
4-48	8.3	437	....	....	....	....	....	....	....	....
5-40	10	531	....	....	....	....	....	....	....	....
5-44	13	552	....	....	....	....	....	....	....	....
6-32	12	542	....	....	....	....	....	....	....	....
8-32	21	790	....	....	....	....	....	....	....	....
10-24	26	988	....	....	....	....	....	....	....	....
10-32	34	1,129	....	....	....	....	....	....	....	....
12-24	43	1,228	....	....	....	....	....	....	....	....
1/4-20	60	1,620	67.0	1,750	76.8	2,200	130	3,500	130	3,800
1/4-28	73	1,854	76.3	2,000	96.8	2,500	146	4,000	146	4,350
5/16-18	147	2,672	137	2,900	170	3,600	266	5,750	266	6,300
5/16-24	167	2,968	152	3,200	193	4,000	293	6,400	293	6,950
3/8-16	229	3,952	245	4,250	305	5,350	470	8,550	470	9,300
3/8-24	281	4,480	277	4,850	346	6,050	536	9,650	536	10,550
7/16-14	390	5,428	392	5,850	491	7,350	766	11,750	766	12,750
7/16-20	....	....	438	6,550	546	8,200	844	13,050	844	14,250
1/2-13	....	....	598	7,800	749	9,800	1,156	15,600	1,156	17,050
1/2-20	....	....	674	8,800	844	11,000	1,307	17,500	1,307	19,150
5/8-11	....	....	1,152	12,450	1,410	14,450	2,170	22,600	2,388	27,100
5/8-18	....	....	1,344	14,100	1,595	16,400	2,454	25,600	2,610	30,700
3/4-10	....	....	2,118	18,350	2,502	19,400	....	....	4,092	40,100
3/4-16	....	....	2,376	20,500	2,790	23,850	....	....	4,560	44,750
3/4-9	....	....	3,408	25,400	....	....	....	....	6,030	53,150
3/4-14	....	....	3,768	28,000	....	....	....	....	6,690	58,550
1-8	....	....	5,112	33,350	....	....	....	....	9,072	69,700
1-14	....	....	5,712	36,450	....	....	....	....	10,140	76,250

\*Based on 84,000 psi min tensile strength and 67,000 psi min yield strength for screw sizes 2 through 5; 71,000 psi min tensile strength and 57,000 psi min yield strength for sizes 6 through 10; 64,000 psi min tensile strength and 52,000 psi min yield strength for sizes 12 through 1/4. Max hardness: Rockwell 100B; Brinell 241.

†Based on 55,000 psi min tensile strength and 44,000 psi min yield strength. Max hardness: Rockwell 95B; Brinell 207.

‡Based on 69,000 psi min tensile strength and 55,000 psi min yield strength for 1/2 in. and smaller sizes; 64,000 psi min tensile strength and 52,000 psi min yield strength for sizes 3/4 to 1 in. Max hardness:

Rockwell 100B; Brinell 241.

§Based on 110,000 psi min tensile strength and 85,000 psi min yield strength for sizes 1/2 in. and smaller; 100,000 psi min tensile strength and 80,000 psi min yield strength for size 3/4 in. Hardness: Rockwell 95-104B; Brinell 207-269.

\*\*Based on 120,000 psi min tensile strength and 85,000 psi min yield strength for sizes 3/4 in. and smaller; 115,000 psi min tensile strength and 75,000 psi min yield strength for sizes 1/2 to 1 in. Hardness: Rockwell 22-32C or Brinell 241-302 for sizes 3/4 in. and smaller; Rockwell 22-32C or Brinell 235-302 for sizes 1/2 to 1 in.

on the order of 25,000 to 30,000 psi at room temperature in the annealed condition. They also have high coefficients of thermal expansion, and are particularly susceptible to galling. Bolting for austenitic flanges may be either of ferritic or austenitic materials, depending on the service temperature.

Since the thermal coefficients of expansion for austenitic materials are 25 to 60 per cent greater than for ferritic steels, austenitic bolting should be selected for service at temperatures over 450 F. However, the use of austenitic bolting presents a definite problem of satisfactorily seating gaskets with a low yield strength material. Ferritic bolting is, therefore, the best choice for use with austenitic flanges for service at temperatures of 450 F and lower. This choice circumvents the difficulty of satisfactorily pretightening without exceeding the yield point. It also limits the differential expansion

effects to a degree, and experience has indicated it to be satisfactory for operation. Austenitic bolting should never be used with flanges of ferritic materials since the differential expansion effects will loosen the bolts in the joint.

**Torque-Tension Relationships:** Table 4 provides a rather comprehensive listing of representative torque and breaking-load data for screw sizes from No. 2 through 1 in. in both coarse and fine thread series. These data are compared to physical property specifications for SAE Grades 1, 2, 3, and 5.

The primary purpose of tightening operations is to give the bolt (by elastic elongation) sufficient internal tensile loading to enable it to withstand any external load it may be called upon to bear in service. It has been shown repeatedly that improperly loaded bolts fail quickly from fatigue while prop-

erly loaded bolts withstand millions of external stress cycles. Torques considerably below a specified minimum may invite fatigue failure.

For this reason, in many critical fastening operations, power-tool tightening is followed by a hand check with a torque wrench preset to the minimum specification. Different tightening operations show a considerable variation in torque. The variation pattern differs with type of tool, type of operation, and a number of other factors.

Another complication arises from friction variation. This may be caused by dimensional tolerance variations, fastener design, surface conditions, thread imperfections, and other factors. All of these have an effect on final torque.

A properly tightened nut is one that applies a tension load that is equal to or greater than the external load that is to be supported in service. When this condition is ful-

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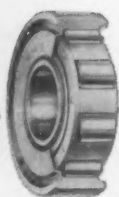
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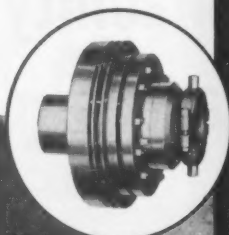
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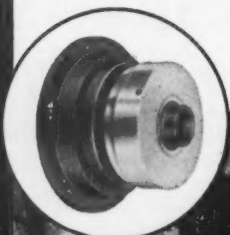
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Circle 470 on Page 19

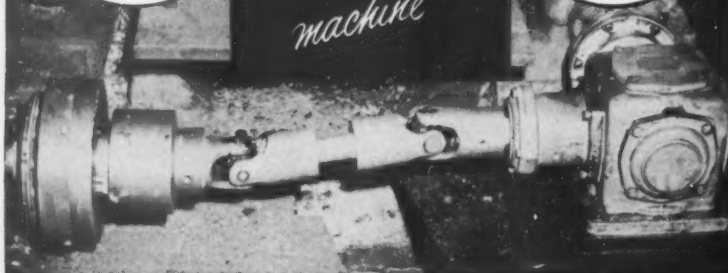
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Circle 471 on Page 19

## DESIGN ABSTRACTS

filled and maintained, the bolt cannot fail by fatigue because it can experience practically no change in stress regardless of the fluctuating nature of the operating load. It cannot fail statically because, to be tightened as specified, it must be capable of supporting the greatest operating load.

In flexible type joints, initial tension will not prevent stress variation in the bolt. In these cases, the bolt should not be preloaded excessively since the preloading will not eliminate the stress variation as it does in the rigid type joint. Excess preloading in the flexible joint will increase the bolts susceptibility to fatigue.

Torque values are affected by the nature of the mating surfaces on the bolt and nut. Different and various nonrealistic torque values obtained in otherwise identical fasteners result from nonuniform surface conditions from piece to piece. Therefore, in setting up torque standards, uniform surfaces with uniform surface treatments and therefore uniform friction, must be provided to obtain relative and realistic results.

Many metal-to-metal joints, if the metals have a high modulus of elasticity, can be considered as rigid joints. In such joints, external or additional loads have very little effect on the bolt stress, provided that the additional loads are less than the load put in the bolt by tightening.

The force required at assembly is not exerted by the bolt unless the bolt is properly tightened. A bolt capable of withstanding a load of 10,000 lb must be tightened to that point. Bolt failures in service are frequently the result of insufficient or improper tightening. Nothing is gained by selecting a strong bolt and then using only a part of its strength.

In nonrigid types of joints, such as gasketed joints or joints made of low modulus materials, external loads are partially additive to the original bolt load. In these cases it is necessary that the bolt have extra unused capacity above the tightening load.

There is some controversy as to the ultimate point to which a bolt may be safely tightened. The great-

est number of engineers feel that the bolt should not be tightened beyond a point just under its yield strength. In determining the extent of tightening, bear in mind that steel bolts will stretch 0.001 in. per in. of stressed grip length for each 30,000 psi of stress. The tightening stress is not always easy to determine by this rule and a common substitute method is the use of the torque wrench. This involves performing a test by torquing a specimen bolt to its yield strength and then taking from 75 to 80 per cent of this figure as the working torque.

**Shear Loading:** There are many instances encountered in design where resistance to shear is a factor. Shearing forces applied to joint elements will not result in slippage if the frictional resistance produced between the members by fastener tension is greater than the shearing forces.

A common belief is that where shearing forces are possible the bolt must have a body diameter only slightly under the hole size. In a rigid joint this is not necessary since the force that resists shear is a component of the clamping force between the head of the fastener and the nut or tapped hole. This ability to resist shear also depends to a large extent on the coefficient of friction of the mating surfaces of the parts being fastened.

Therefore, the diameter relationship between the hole and the fastener which goes into it is only important in shear if slippage occurs. Then, the bolt-body diameter may be of the undersized variety but not less than the pitch diameter of the threaded section.

"Strength Considerations in Fasteners," presented at the Industrial Fastener Applications Institute, University of Wisconsin, Madison, Wis., November, 1959, 19 pp.

## hydraulic

### Hydraulic Fluid Properties And System Performance

W. W. LeRoy, Senior Test Engineer, and R. L. Leslie, Supervisor, Fluids and Chemistry Lab., Vickers Inc.

Flow characteristics of the fluid in a hydraulic system and the reaction

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- ★ Serve as an electrical conductor which is readily machinable and can operate satisfactorily up to 6,000°F.

## No Other Material Can Do ALL of These:

- ★ Resist corrosive action of most gases and chemicals.
- ★ Serve as a semi-permanent, readily-formed mold for casting metals or glass.
- ★ Act as a seal ring around a moving shaft to retain liquids and gases.
- ★ Operate as a sliding contact on commutators and slip rings.
- ★ Serve as a bearing material for vacuum applications or as an insert in ordinary bearings.
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### DESIGN ABSTRACTS

of the fluid in a servo system; the effect of fluid viscosity and density on flow conditions and vapor pressure; air solubility effects on system performance; the effect of density and compressibility on servo systems.

*Presented before the 15th Annual Meeting of the National Conference on Industrial Hydraulics, at Vickers Inc., Detroit, October, 1959, 18 pp.*

## mechanical

### Optimum Design of Shells

R. T. Shield, Associate Professor of Applied Mathematics, Brown University

Procedures for the optimum design of an elastic-plastic shell (or structure) which carries direct stresses, or bending stresses, or both. The design is sought which supports given loads and which is the optimum design for a given criterion. A general form is taken for the criterion and it includes minimum volume, minimum weight, and minimum moment of inertia about an axis as special cases. The design procedure is obtained through the use of limit analysis which greatly simplifies the establishment of the procedure. In the case of the sandwich shell it is shown that the procedure leads to an absolute minimum rather than to a relative minimum. Applications of the procedure indicate that only for relatively short shells does the minimum-volume design effect an appreciable saving over either the design with constant thickness or the membrane design.

*ASME Paper No. 59-A-47, presented at the Annual Meeting, Atlantic City, N. J., November, 1959, 7 pp.*

### Plastic Behavior of Rotating Cylinders

F. P. J. Rimrott, Dept. of Strength of Materials, National Research Council of Canada

Equations for strain and stress distribution in hollow rotating cylinders. There are three possible modes of plastic failure: Instability, cleavage, and shear fracture. At instability, the speed reaches a maximum. If this maximum speed is maintained or exceeded, the cylinder will deform at a very high rate and soon fracture. Fracture by cleavage will likely begin as a subsurface fracture close to the bore. Shear

fracture is initiated at points where the absolute maximum shearing stress is the largest at constant mean normal stress, and at points where the mean normal stress is the largest at constant maximum shearing stress.

ASME Paper No. 59-A-65, presented at the Annual Meeting, Atlantic City, N. J., November, 1959, 7 pp.

### Vibration Characteristics Of a Mechanical Connection

Arthur Sorensen Jr., Research Engineer, Environmental Laboratory, AC Spark Plug Div., GMC, Milwaukee

Behavior of a simple mechanical connection over an extended frequency range with particular reference to vibration transmission and isolation. The suitability of a connection as a vibration transmitter improves with an increase in the weight ratio and a decrease in the operating frequency. Its effectiveness as a vibration isolator improves with a decrease in the weight ratio and a reduction in the isolation range. The latter is accompanied by an elevation of the lowest (and a corresponding depression of the highest) frequency which can be effectively isolated.

ASME Paper No. 59-A-41, presented at the Annual Meeting, Atlantic City, N. J., November, 1959, 8 pp.

## processes

### Flash-Welded Aluminum-Copper Joints at High Temperatures

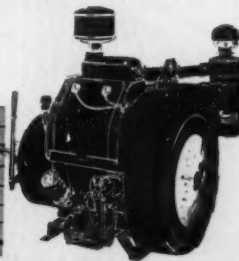
C. R. Dixon and F. G. Nelson  
Alcoa Laboratories, New Kensington, Pa.

Results of tests on welds made with improved techniques, especially in the forging mechanism. Average strengths of the welds are at least 10,000 psi when heated as high as 300 F for 2 years, 370 F for 1 year, 450 F for 144 hr, 500 F for 36 hr, 600 F for 2 hr, or 700 F for 5 minutes. The strengths of individual welds, however, may drop below 10,000 psi when joints are heated 48 hr or more at 500 F or when heated for shorter times above that temperature. There was no evidence of embrittlement at any of the heating conditions.

AIEE Paper No. 59-1162, "The Effect of Elevated Temperature on Flash-Welded

How you can materially improve  
your product dependability  
by specifying

# CUSTOM ENGINEERED



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You always simplify the job of building consumer preference into a powered product, by making Wisconsin an active member of your design team.

Not only is Wisconsin the exclusive air-cooled, four-cycle engine line that's world-renowned for complete dependability, but it provides you the broadest range of torque/horsepower ratings in the industry. Twelve basic designs, covering singles, twins and V4's, meet any requirement from 3 through 56 hp. — from displacements of 14.9 through 255 cu. in. — each with peak torque in the rpm range that assures maximum lugging power!

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### WISCONSIN MOTOR CORPORATION

MILWAUKEE 46, WISCONSIN  
World's Largest Builders of  
Heavy-Duty Air-Cooled Engines



### WISCONSIN CUSTOM-ENGINEERED ACCESSORIES, TOO

**DRIVE TRAIN:** specify your choice of centrifugal clutch; over-center clutch; clutch reduction in a variety of ratios; reduction assembly; adaptor to take a spring-loaded clutch or transmission-torque converter designs.

**SPEED REGULATION:** available in a broad range of governor controls; hand-operated, remote wire-and-lever controls; 2-speed agricultural controls (idle and load speed) and special provisions to mount controls of your own design.

**FUEL SYSTEMS:** you choose between gasoline, natural gas and LPG (for domestic application) and alcohol, kerosene, and No. 1 fuel oil (for export).

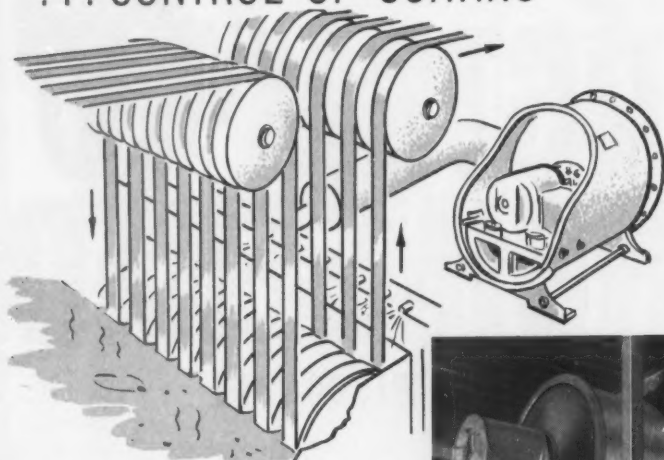
**HYDRAULIC POWER:** all Wisconsin V4's can be equipped with integrally-mounted hydraulic pump.

**ELECTRICAL EQUIPMENT:** you can select 6 or 12-volt starter-generator systems for all models, 3 through 56 hp. Solenoid switches and automatic choke, for remote or automatic starting, are also available.

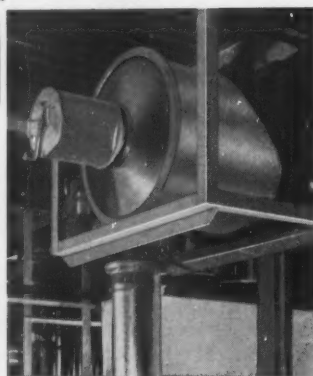
Let our application engineers assist you in building the Wisconsin engine design that's custom-engineered to your machine and your specific operating conditions. Tell us your problems; you'll like our engineering cooperation, our desire to work with you in making yours the wanted product.

Write for your copy of Wisconsin Bulletin S-249 with data covering complete Wisconsin line. Address Dept. O-10.

*The problem in planning production  
equipment at Stanley Steel Strapping  
... CONTROL OF COATING*



**SPENCER BLOWERS**  
*supplied the  
sensible solution*



As a final operation in the finishing of steel strapping, it is necessary to lightly and evenly coat the strapping with wax. The obvious problem: how to control the amount of wax . . . specifically, how to prevent coating too heavily.

Incorporating a Spencer blower into the equipment solved the problem. Through a special nozzle arrangement, high volume, low pressure air is delivered against the strapping as it emerges from the final automatic dipping. Excess wax is blown off (and back into the tank) . . . thus reducing costly waste and providing precise quality control of the finished product.

Spencer will be glad to assist in adapting standard blowers—or developing special units—to meet *your* particular needs.



Request Catalog #1268 containing complete specifications on Spencer blowers, available in standard capacities of:

1/3 to 1,000 H.P.  
Up to 20,000 C.F.M.  
4 oz. to 10 lbs. pressure



**The SPENCER**  
**TURBINE COMPANY**  
HARTFORD 6, CONNECTICUT

DESIGN ABSTRACTS

*Aluminum-Copper Joints," presented at the AIEE Fall General Meeting, Chicago, October, 1959, 7 pp.*

**techniques**

**Static Grid Method Applied To Dynamic Stress Problems**

A. J. Durelli, J. W. Dally,  
and W. F. Riley, Armour Research  
Foundation

A rubber-thread grid network in a low-modulus model material is used in conjunction with a micro-flash light source to record grid distortions and photoelastic fringe patterns. Static analysis procedure is: 1. A network of lines (rubber threads) is embedded in the model material. 2. A no-load photograph is taken of the model to record the undeformed state of the grid. 3. A photograph is taken under load to record the deformed state of the grid. 4. The grid-line positions are measured on both load and no-load photographs to within  $\pm 0.0003$  in. 5. Differences are made between the two sets of measurements to obtain the displacement fields. 6. The displacement fields are differentiated to obtain the strain fields. 7. The strain fields are converted to stress fields by using Hooke's law and suitable values for the modulus of elasticity and Poisson's ratio.

The dynamic grid method differs only in steps 3 and 7. In the dynamic case, a photograph is taken over a very short exposure time, and at a number of different times after the application of the time-dependent load.

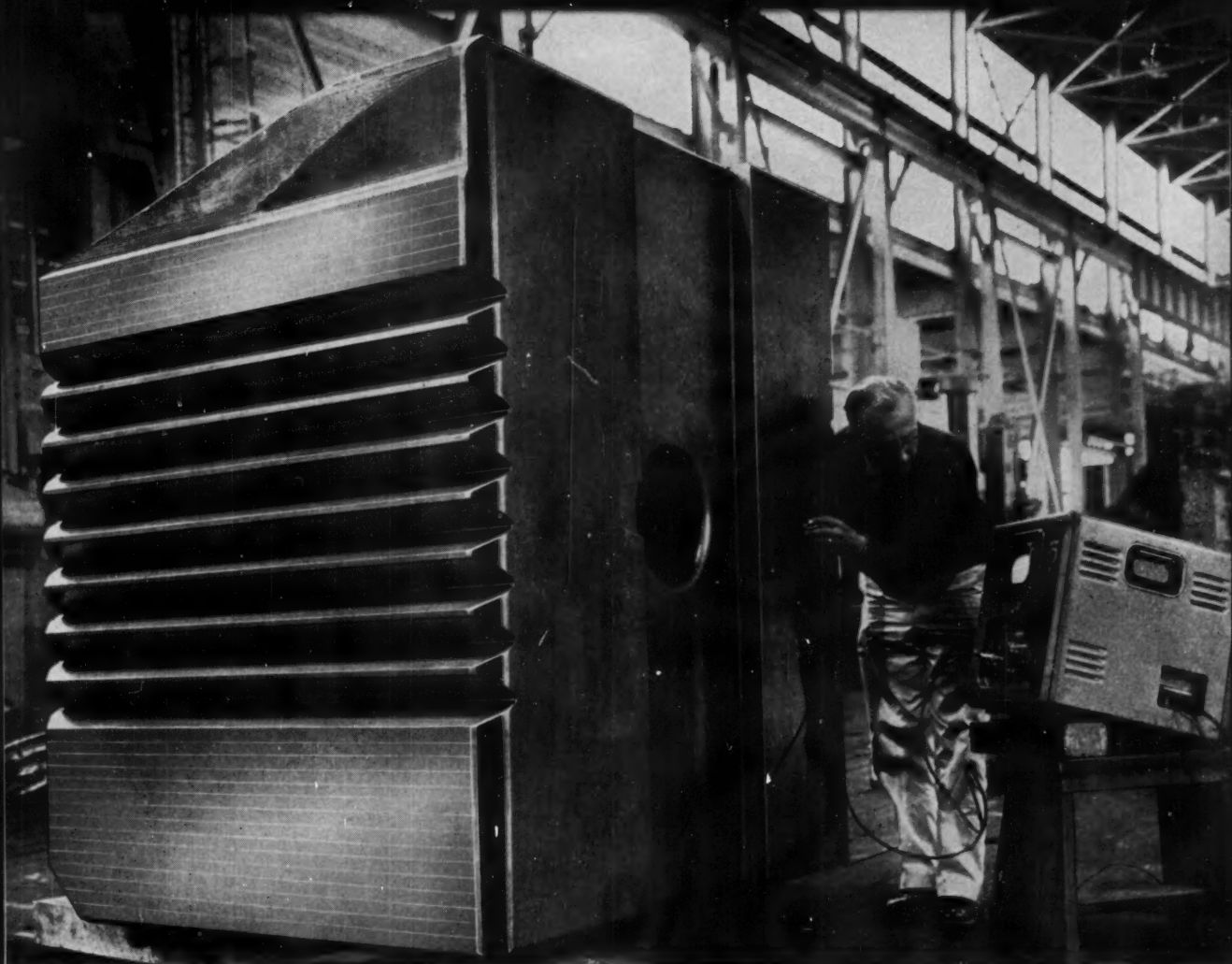
ASME Paper No. 59-APMW-1, "Developments in the Application of the Grid Method to Dynamic Problems," presented at the West Coast Conference of the ASME Applied Mechanics Div., Stanford, Calif., September, 1959, 6 pages.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.

University of Wisconsin, University Extension Div., 3030 Stadium, Madison, Wis.



## We think it's the largest forged hammer ram ever made

- It weighs in at 50,000 pounds. And it measures 54 $\frac{1}{4}$  inches from top to bottom—59 $\frac{3}{4}$  inches from side to side—66 inches from front to back. Here at Bethlehem, we've never heard of a larger *forged* hammer ram. Have you? If so, we'd certainly like to know the details. Would you be good enough to drop a line or two to Forgings Sales? (And end our suspense over whether we've chalked up another record, or an also-ran?)

A few other facts about this hammer ram: we forged it from nickel-chrome-molybdenum-vanadium steel; we heat-treated and tested it to our customer's specifications; and, as you can see, we furnished it finish-machined, ready to

start pounding in a steam drop hammer.

Although this ram is surely a giant in its class, it's a pygmy compared to some of the forgings we've made. Our shops turn out the largest forgings ever needed—some weighing over 200 tons. (Some of the smallest, too—drop forgings, for example, that weigh as little as one pound.)

Call us when we can be of service to you or members of your staff. Our engineers will gladly cooperate, from the planning stage to the finished product—whatever the type, size, or design of forging you require.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

# BETHLEHEM STEEL



# Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

## Leak Detectors

Pressurized enclosures are easily tested for leaks with halogen leak detectors. Procedures and equipment for testing are thoroughly described in Bulletin GET-2936 on Type H detectors, which also covers sensitivity requirements and hazard limitations. 6 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 601 on Page 19

## Pulse Code Telemeter System

Bulletin CP 3707 presents diagrams and photos showing several applications of telemetering systems for transmitting required data quickly over long distances. Liquid level of vats, temperature or pressure of systems, and other critical data are read from remote stations. 12 pages. Vapor Recovery Systems Co., 2820 N. Alameda, Compton, Calif. L

Circle 602 on Page 19

## Shielded Motors

Newly developed Multi-Shielded motors replace totally-enclosed motors in many applications where conditions of moisture, dust, oil, and chemicals prevail. Bulletin 196 illustrates construction and presents economic advantages. 4 pages. Sterling Electric Motors Inc., 5401 Telegraph Rd., Los Angeles 22, Calif. L

Circle 603 on Page 19

## Static Inverter Supply

Model SIS-40613-S features reverse-voltage protection, automatic voltage regulation, and solid-state component construction. The power inverter operates from a 28-v dc source and provides regulated 26-v, 400-cps three-phase output at 20 va per phase. Bulletin S-1035 shows photo and includes specifications and functional description. 2 pages. Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y. D

Circle 604 on Page 19

## Reduced Port Sleeves

Streamlining flow patterns of slurries in lines requiring a size reduction is important in minimizing abrasion and corrosion problems. Bulletin M-1 describes a new rubber pinch valve available in standard sizes from 1 x 2 in. to 6 x 8 in. 1 page. Red Jacket Co. Inc., 500 Bell Ave., Carnegie, Pa. F

Circle 605 on Page 19

## Water & Refrigerant Coils

Catalog 5559 is a liberally illustrated publication on water and direct-expansion refrigerant coils. Included are exclusive construction features, selection procedures, coil performance data, mean effective tem-

perature difference chart, psychometric chart, total heat table, physical and dimensional data, piping diagrams, and architectural and engineering specifications. 28 pages. Young Radiator Co., Racine, Wis. J

Circle 606 on Page 19

## Control Knobs

Panel hardware, electrical components, and control knobs are listed and illustrated. Drawings and dimensions are included. 4 pages. Raytheon Co., Industrial Apparatus Division, 100 River St., Waltham 54, Mass. B

Circle 607 on Page 19

## Flame-Retarding Plastic

Bulletin 3.1.1. lists physical, mechanical, and electrical properties of Fireban X, a flame-retardant, paper base, phenol-resin laminate. The material is available in sheets 49 x 49 in., up to 1 in. thick. Suggested uses include terminal boards or panels and structural parts for radio, aircraft, and switchgear. 2 pages. Taylor Fibre Co., Norristown, Pa. E

Circle 608 on Page 19

## Hose and Fittings

Industrial catalog covers a complete range of hose types, fittings, adapters, self-sealing couplings, and accessories. Featured in catalog 204 is a hose-selector chart, listing various applications and fluids for which specific hose types are recommended. Instructions for ordering and for assembling hose lines are also provided. 40 pages. Aeroquip Corp., Jackson, Mich. T

Circle 609 on Page 19

## Regulated DC Power

Application of modern regulated rotary-power devices for dc requirements at different voltage levels is presented with details and examples in brochure. Simple initial installation, cool operational characteristics, and low maintenance are stressed in Precise-Power equipment application. Components are described fully in eight bulletins listed as Brochure 59-P. 34 pages. Electric Specialty Co., 211 South St., Stamford, Conn. B

Circle 610 on Page 19

## Word-Indicator Lights

A large-legend Roto-Tellite has been added to the line of off-the-shelf word-indicator lights. Use is in feedback of critical information on control panels at missile launch sites, computers, ships, submarines, and aircraft. Visible legend area will accommodate up to three rows of 0.125-in. high characters, 14 per row.

Catalog 159C includes detailed description, basic circuits, mounting dimensions, and tear-out sheet for requesting print of user's application. 16 pages. Master Specialties Co., 956 E. 108th St., Los Angeles 59, Calif. L

Circle 611 on Page 19

## Rotary Solenoids

Used as the prime energy source in aircraft, missiles, and industrial systems where an instantaneous, high-torque rotary force is required, Pacsol solenoids are described on Separate Engineering Data Sheets for a 70 and a 150-in.-lb.-degree unit. Sheets contain list of operational characteristics, drawings, and torque charts. 2 pages each. Illinois Tool Works, Pacsol Division, 3155 El Segundo Blvd., Hawthorne, Calif. I

Circle 612 on Page 19

## Casters

Bulletin 604 features a light-duty series caster available in a variety of wheels from 1½ to 8-in. diam. Single ball-race swivel-mount and companion rigid-mount casters can be selected with capacities from 50 to 800 lb. Medium-duty series also listed, with capacities up to 2500 lb. 4 pages. Payson-Harris & Reed Inc., 2916 W. Jackson Blvd., Chicago 12, Ill. I

Circle 613 on Page 19

## Air Filters

Bulletin 207 presents construction features and application data on permanent washable-unit air filters for various systems. Special filters are shown for use with radar, electronic cabinet ventilation systems, and aircraft engine intakes. 12 pages. American Air Filter Co. Inc., 215 Central Ave., Louisville 8, Ky. G

Circle 614 on Page 19

## Counting Devices

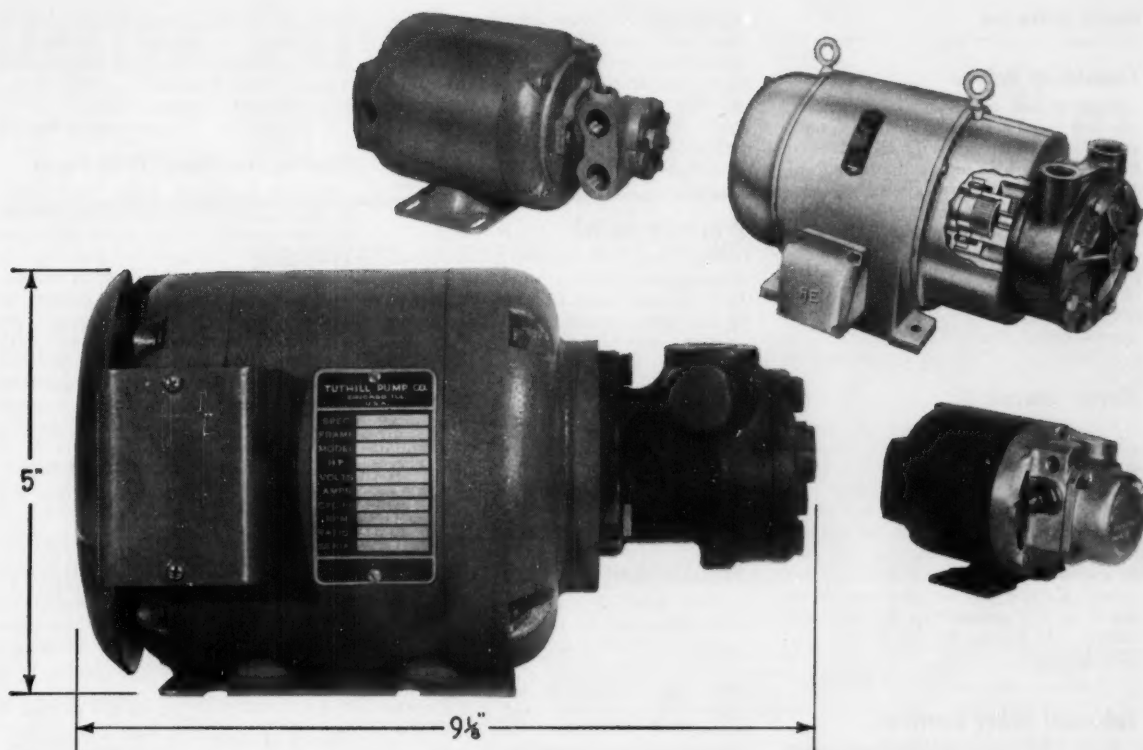
Advantages for including counting devices in the design of machinery are emphasized in folder entitled "A Fresh Edge on Competition." Described are revolution, geared, ratchet, and other types of counters which provide precise information on machine's functions. 8 pages. Veeder-Root Inc., Hartford 2, Conn. B

Circle 615 on Page 19

## Jet Pump Motors

Cutaway illustrations show features of the line of GE jet pump motors covering the range of 1/3 through 2 hp. Rating construction details and dimensions are also shown in Bulletin GEA-5902D. 6 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 616 on Page 19



## NEW pump & motor combination adds to TUTHILL'S complete close-coupled line

The new Series 42 shown above further extends Tuthill's complete line of close coupled pump and motor units. These compact combinations have been especially developed to solve design problems and cut costs in hydraulic, oil burning, lubrication and a wide variety of other services.

As shown above, this compact new unit has overall measurements of only 9 1/4" by 5". The totally enclosed motor is supplied with ratings of from 1/12 to 1/6 hp, while the pump units have a capacity of 1/3 to 3 gpm. The Series 42 may be supplied either with or without a built in relief valve.

Some other models in Tuthill's line of close coupled combinations are also shown above. These include a broad selection of units with capacities up to 50 gpm, for pressures to 500 psi.

### Save space, weight and money

The compact design of these units solves tough design problems. The elimination of couplings, bases and adapters results in significant savings. The reduction of weight lowers shipping costs. And their compactness often simplifies assembly operations for further savings in production costs.

### Available from stock

All the units shown above, plus many others are immediately available from stock. There is no minimum quantity requirement . . . so you can use these economical units in a wide variety of applications.

### "POWERMITE" for OEM applications

For original equipment applications involving substantial production runs, Tuthill offers further savings in space and weight through the use of the POWERMITE. This is an exclusive Tuthill design in which pump and motor are incorporated into one unit, which takes up no more space and weighs no more than a conventional motor. For example, the Powermite shown at lower right above, measures only 8 1/6" by 4 3/4" . . . has a capacity of 16 gph at 350 psi.

Tuthill's engineers will be happy to develop a Powermite specifically designed for your OEM application . . . providing the greatest possible saving in space and weight.

If you are trying to incorporate a pump and a motor into a limited space Tuthill has the answer. An experienced Tuthill field engineer will be happy to give you the details. Write today.

*Tuthill manufactures a complete line of positive displacement rotary pumps in capacities from 1/3 to 200 GPM; for pressures to 1500 PSI; speeds to 3600 RPM.*



## TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois



### Time-Delay Relays

Standard and special applications, sizes, selection guide, and circuit descriptions are comprehensively covered in illustrated Bulletin 5905 on Tempo's line of adjustable electronic time delay relays. Accuracy and reliability requirements of military and industrial electronic systems are met by these high performance components which are available in overlapping ranges for optimum flexibility. 8 pages. Tempo Instrument Inc., Commercial Street, Hicksville, N. Y. D

Circle 617 on Page 19

### Motor Controls

A complete product listing of manual and magnetic starters, pressure switches, pushbuttons, control stations, and accessories is available in Catalog 5900. Featured are quick selector charts for motor starters that include full heater coil information for each motor size and rpm in addition to enclosure choices and list prices. Catalog also includes new design size 0 to 1 1/4 nonreversing and reversing starters. 72 pages. Furnas Electric Co., 1045 McKee St., Batavia, Ill. I

Circle 618 on Page 19

### Spherical Roller Bearings

Book 2760 describes Link-Belt's new line of highest capacity spherical roller bearings in complete detail and includes comprehensive selection data, load ratings, diagrams, photographs, and charts. The new spherical bearing design combines three features: Maximum diameter and quantity of convex rollers for each bearing size, precision-machined, centrifugally case bronze retainers, and high, heavy inner-race shoulders. 52 pages. Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill. J

Circle 619 on Page 19

### Power Connectors

Series 14, 16, EZ, and GA rectangular power connectors reviewed in technical Catalog 1416 are designed for heavy duty applications in guided missiles, aircraft, and electronic equipment. Data cover complete specs, outline dimensions, and general information. 20 pages. DeJura-Amsco Corp., Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 620 on Page 19

### Electrolytic Capacitors

Type SCM electrolytic capacitors of the solid-electrolyte, porous sintered-tantalum anode type are described, illustrated, and fully specified in catalog. Included are performance and application data curves. 14 pages. Texas Instruments Inc., Semiconductor Components Div., Box 312, Dallas, Tex. P

Circle 621 on Page 19

### Insulation

Thermal insulations for industrial and commercial applications ranging from -400 to 3000 F are completely described in Catalog IN-244A. Six sections, conveniently tabbed for reference, divide the

catalog into specialized groups of insulations, each containing application photo, description, available materials, advantages, and detailed specification data including compliance with government specifications and ASTM Standards. 54 pages. Johns-Manville Sales Corp., 22 E. 40th St., New York 16, N. Y. D

Circle 622 on Page 19

### Proximity Switch

New device detects the proximity of ferromagnetic material without detaining its flow, and senses an unlimited variety of sizes, from automotive frames to bottle caps. Sensor detection range is from 1/16 to 1/2 in. Signal amplifier may be located up to 150 ft from sensor. Data sheet 163 gives photograph, drawings, sensitivity range diagrams, sensitivity envelopes, and mounting and wiring instructions. 4 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 623 on Page 19

### Flexible-Shaft Assemblies

More than 180 variations of flexible-shaft assemblies are cataloged for a wide variety of standard applications. Brochure 574 lists capacities and illustrates monodirectional, bidirectional, and panel-mount assemblies made from stock components. 8 pages. F. W. Stewart Corp., 4311 Ravenswood Ave., Chicago 13, Ill. J

Circle 624 on Page 19

### Conveyor Chain

A comprehensive engineering manual and reference booklet is available for use in the selection, installation, and operation of conveyor chain systems. Included are principal features and illustrations of the most popular types of chains, examples of conveyor types, shaft selection charts, and a trouble shooting chart. A brief history of chain development is also given. 36 pages. Moline Malleable Iron Co., St. Charles, Ill. L

Circle 625 on Page 19

### Clutches & Brakes

Data sheet AIM 959 lists specifications and dimensions of miniature electromagnetic brakes and clutches for use on multispeed devices, direction changers, and machine tool controls. Units operate on 28 v dc. 4 pages. Autotronics Inc., Box 208, Florissant, Mo. I

Circle 626 on Page 19

### Air Valves

Versatility of Type D Pilotair valve assemblies is stressed in a new catalog listing basic valves and operators. Many combinations are indicated, along with dimensions, diagrams, and JIC symbols. 16 pages. Westinghouse Air Brake Co., Industrial Products Div., Wilmerding, Pa. F

Circle 627 on Page 19

### Fasteners

Assembly ease and speed, using production fasteners for such applications as sheet-metal panel joints, tubing and wire fastening, and retaining moldings are illustrated and discussed in new brochure. Expanded line of standard self-retaining

fasteners has been developed for use in manufacture of appliances, automobiles, farm implements, toys, and many others. 8 pages. Robin Products Co., 27027 Groesbeck Highway, Warren, Mich. T

Circle 628 on Page 19

### Oscillograph Direct Print Paper

Kodak's Linagraph direct print paper, a photographic material which provides an immediately visible record of certain oscillograph tracings is described in Pamphlet P-40. Made for use in moving-mirror oscillographs which employ an ultraviolet light source, Linagraph can accommodate writing speeds up to 100,000 ips. The record can be stored, protected from ambient light, or it can be processed with Permanizing developer. 4 pages. Eastman Kodak Co., Photo Recording Methods Sales Div., Rochester 4, N. Y. N

Circle 629 on Page 19

### Transistors

Complete application and performance characteristics for Fairchild semiconductor diffused silicon mesa transistors are presented in reference form. Each type of transistor is stocked for immediate shipment. 4 pages. Schweber Electronics, 60 Herricks Rd., Mineola, L. I., N. Y. D

Circle 630 on Page 19

### Panel Meters

Performance characteristics, specifications, prices, and drawings are shown in data sheet covering 3 1/2-in. panel meters. Voltmeters, ammeters, microammeters, and milliammeters in 61 standard models are available. 6 pages. Beckman Instruments Inc., Helipot Div., 2500 Fullerton Rd., Fullerton, Calif. L

Circle 631 on Page 19

### Water Pump

Low cost, compact, sealless, centrifugal water pump of bronze and stainless-steel construction, requiring no lubrication, is described in Bulletin 420-D. "Canned" construction, capacity, and dimensions are also shown. 2 pages. Fostoria Corp., Dynapump Div., Box 35-4, Huntingdon Valley, Pa. E

Circle 632 on Page 19

### High-Pressure Pumps

Series D, two stage Chempumps, designed for leakproof pumping at heads up to 600 ft, pressures to 3500 psi, and temperatures to 850 F, is presented in Bulletin 1080. Performance curves and design features for these "canned" pumps are included. 4 pages. Fostoria Corp., Chempump Div., P. O. Box 35-2, Huntingdon Valley, Pa. E

Circle 633 on Page 19

### Flexible Couplings

High-tensile, aluminum-alloy flexible couplings are designed for operating temperatures up to 700 F. Accurately balanced couplings are sparkproof and are rated at 3000 rpm and higher, depending upon size. Brochure contains selection information, ratings, and physical dimensions. 4 pages. Van Gelder Mfg. Inc., Gelder Coupling Div., 3654 Grand Ave., Oakland 10, Calif. L

Circle 634 on Page 19

# Design Data on Resilient Clutch Facings

# 7

## THE EFFECTS OF DIFFERENT OILS IN WET CLUTCHES

To keep performance characteristics constant in any wet clutch, the oil should be chosen carefully. In fact, selecting an oil may be as important as selecting the right friction material.

Figure 1 illustrates how changing oils can alter performance characteristics. Though these oils are products of different manufacturers, both are specified as "Type A Automatic Transmission Fluid." The torque curves for both materials are higher with Oil Y. Obviously, a clutch designed around one of these oils would likely operate much differently in the other.

Figures 2 and 3 compare the friction-speed characteristics for Material B in both oils at various closing pressures. Note that with Oil X, the coefficient of friction rises rapidly as the clutch approaches full engagement, indicating the possibility of a rough, noisy engagement or clutch chatter.

The variations observed in these graphs are common. Most transmission oils contain additives which give each oil unique characteristics. Therefore, once an oil has been chosen it should be used exclusively to avoid differences that may exist, even between two approved oils.

Of course, selection of the transmission oil is just one of many factors that affect clutch performance. For complete information, send for your copy of "Resilient Friction Materials," a new technical manual, just published by Armstrong. It contains 48 pages of charts, graphs, and technical data on using resilient clutch facings, and a check sheet that will help you select the right friction material for your application.

To get your free copy of "Resilient Friction Materials," write to Armstrong Cork Company, Industrial Division, 7202 Dean Street, Lancaster, Penna.

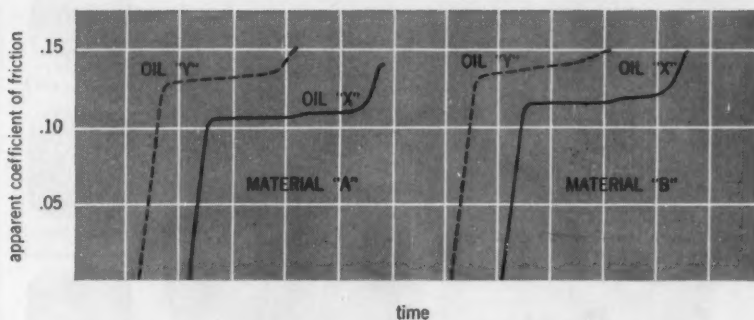
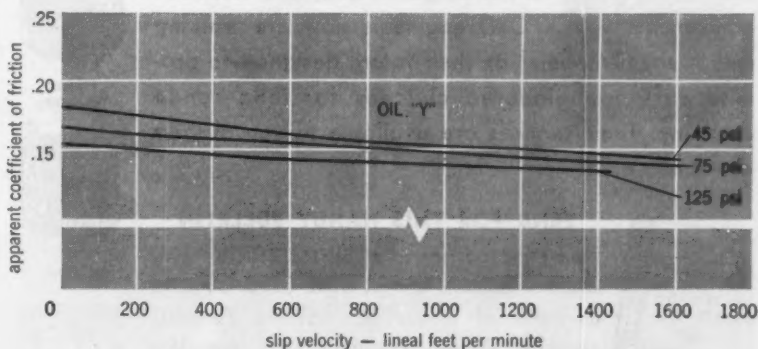
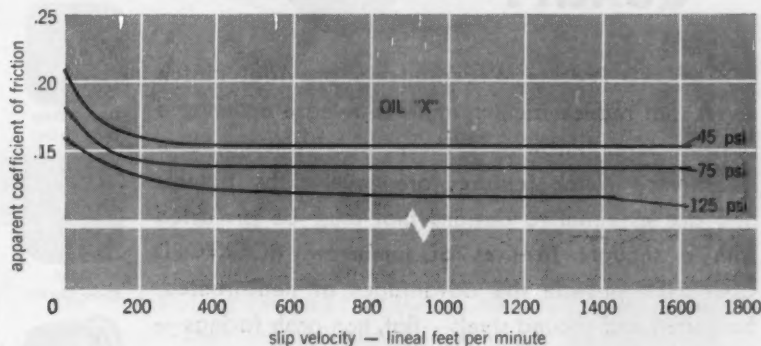


Figure 1. These torque curves show how engagement characteristics and coefficient of friction can be changed by changing from one oil to another, supposedly similar, oil. The curves were produced under identical conditions for each friction material; flat plain plate ( $6\frac{1}{4}$ " I.D. x  $7\frac{1}{2}$ " O.D.), 150 psi pressure, 200° F. oil temperature.

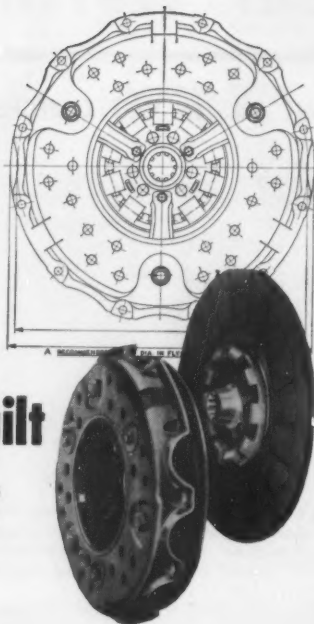
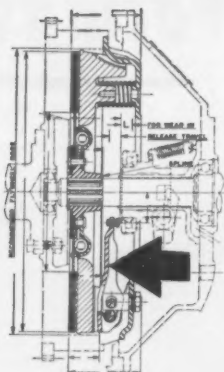


Figures 2 and 3. In these graphs, coefficient of friction is plotted against speed differential between the opposing surfaces during engagement. The clutch facing is Material B from Figure 1. In Oil X (above), at all pressures, the friction value rises rapidly at low slip speeds. In Oil Y, the coefficient of friction is more nearly constant, producing a smoother, quieter engagement.

**Armstrong RESILIENT FRICTION MATERIALS**

1860-1960 Beginning our second century of progress

# ROCKFORD



## Precision Built For Better QUALITY

ROCKFORD Precise Workmanship provides clutch levers that reduce friction, improve release action and prevent lever throw-out. These wear-resisting, life-lengthening clutch features are covered by patents and are essential to designs that must be projected with a thought to uses of tomorrow. ROCKFORD CLUTCHES provide the advantages of heat-treated, hardened and ground steels—flat, non-grab facings—heat dissipation—dirt exclusion—and fine accurate adjustments. ROCKFORD engineers now are working with many companies on their future designs—to provide custom-engineered clutches for long range economy. Their services are available to you at your convenience.



### SEND FOR THIS HANDY BULLETIN

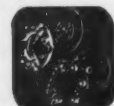
Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

**ROCKFORD Clutch Division BORG-WARNER**

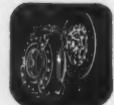
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# CLUTCHES



Small  
Spring Loaded



Automotive  
Spring Loaded



Heavy Duty  
Spring Loaded



Oil or Dry  
Multiple Disc



Heavy Duty  
Over Center



Light  
Over Center



Power  
Take-Offs



Speed  
Reducers



## HELPFUL LITERATURE

### Stainless-Steel Filters

High gas or liquid flow rates with low pressure drops are achieved using porous stainless-steel filters. Featured in Bulletin M-212A are photos and descriptions of numerous custom-designed filters and filter elements. Full specifications on standard filters also given. 4 pages. Pall Corp., Micro Metallic Div., Glen Cove, N. Y. D

Circle 635 on Page 19

### Stepping Devices

Technical Brochure SP9-1 is a well-illustrated guide to the designer on application of stepper motors, switches, pulse counters, interval timers, and positioning devices. Included are product features, construction details, and schematic drawings of application circuitry. 12 pages. A. W. Haydon Co., 232 N. Elm St., Waterbury 20, Conn. C

Circle 636 on Page 19

### Computing System

The RPC-4000 is a fully transistorized, electronic, stored-program, general-purpose computing system for engineering and business data processing. Among the features described in Bulletin S-482 is a memory of over 8000 words. Basic system is comprised of computer and punched paper tape typewriter. 2 pages. Royal McBee Corp., Data Processing Div., Port Chester, N. Y. D

Circle 637 on Page 19

### Snap Action Switch

Particularly useful to control small inductive loads is the compact SS101 snap switch relay with contact ratings of 10 amp, 1/3 hp at 125 v ac. Up to six-pole contact arrangement can be furnished as standard. Brochure includes photo, specification, and drawing. 2 pages. Warco Industries Inc., 6625 Delmar Blvd., St. Louis 30, Mo. I

Circle 638 on Page 19

### Porous Metal

Bulletin BFD-141 details the properties of Poroloy, a high-temperature, corrosion-resistant, high-strength, easily fabricated wound-wire porous metal. A variety of metals including carbon steel can be made into Poroloy. Use is both in filtration and in nonfiltration applications such as long-wearing, low-friction bearings. Technical data are presented in the form of specifications, flow rate curves, and physical characteristics. 6 pages. Bendix Aviation Corp., Bendix Filter Div., 434 W. 12 Mile Rd., Madison Heights, Mich. T

Circle 639 on Page 19

### Digital Recording System

Multipoint digital data recording system described in Bulletin 350-8 was designed for automatic testing of vacuum tubes on a mass production basis. System handles 200 input variables and utilizes 20 input selector modules, each handling 10 variables. 2 pages. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif. L

Circle 640 on Page 19

### Analog-to-Digital Processor

Details of the MicroSADIC high-speed analog-to-digital processor are furnished in Bulletin 3004. Machine acquires, digitizes, and stores data at maximum rate of 10,000 samples per second. 4 pages. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. L

Circle 641 on Page 19

### Heat Exchangers

Catalog Section S-6620 deals with Karbonate impervious graphite immersion heat exchangers and circulating steam jets for heating or cooling corrosive solutions in all types of tanks. Plate, bayonet, and coil type heat exchangers are reviewed. 12 pages. National Carbon Co., 535 Fifth Ave., New York 17, N. Y. C

Circle 642 on Page 19

### Tape Recorder

The PS-300 Series subminiature tape recorder specified in Bulletin 56 measures only 5 x 4 x 2 in. and weighs less than 2 lb. The 2½-w unit has 4-in. diameter coaxially stacked reels which hold 900 ft of ¼-in. ½-mil tensilized Mylar tape. 4 pages. Precision Instrument Co., 1011 Commercial St., San Carlos, Calif. L

Circle 643 on Page 19

### Laminated Plastics

Available grades and properties of Panelyte laminated plastic sheets, rods, and tubes are listed in catalog. The more than 50 laminate grades described include phenolics, melamines, epoxies, and silicones with paper, asbestos, canvas, cotton, nylon, and glass fabric bases. 20 pages. Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich. T

Circle 644 on Page 19

### Refractory Metals

A description of tantalum, titanium, and zirconium in terms of process characteristics and fields of application is available in Bulletin 978. Available standard equipment is illustrated and specified. 8 pages. Pfaudler Permutit Inc., Pfaudler Div., 1104 West Ave., Rochester 3, N. Y. N

Circle 645 on Page 19

### Pressure Reducing Valves

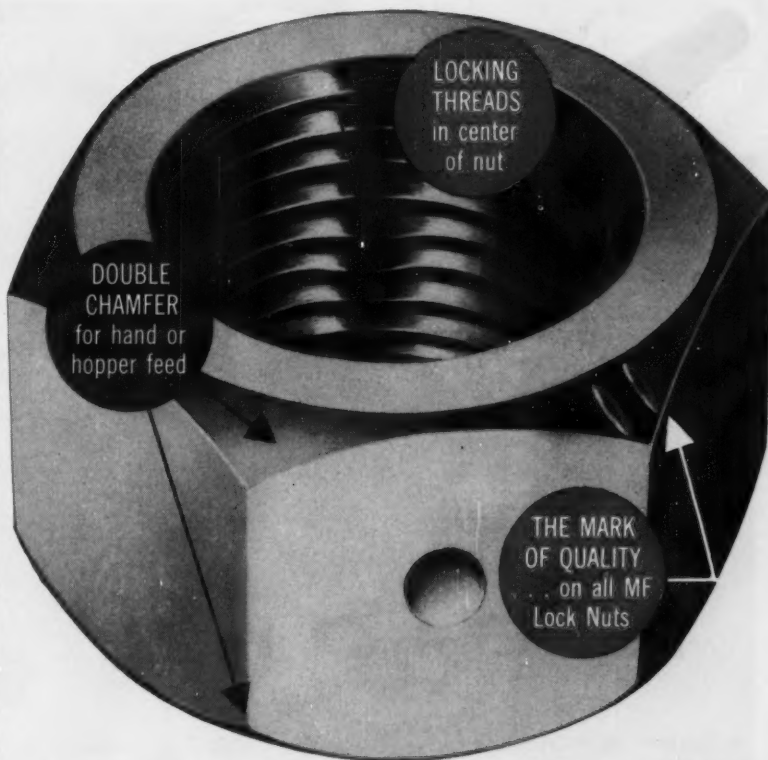
Bulletin reviews No. 171 Type D valves which can be used as pressure reducing or relief valves, or pump governors with steam, oil, water, gas, or air. Bulletin covers features, applications, operation, and installation. 4 pages. Atlas Valve Co., 280 South St., Newark 5, N. J. D

Circle 646 on Page 19

### Solenoid Lock Switches

Application of a solenoid locking mechanism to standard Type JR rotary switches is shown in Data Sheet 18. Solenoids are available for locking switch in any or all positions. Electro Switch Corp., 167 King Ave., Weymouth 88, Mass. B

Circle 647 on Page 19



## Build better products...faster...with MF TWO-WAY LOCK NUTS!

The MacLean-Fogg Two-Way Lock Nut has the features designers and production men want. Check them off: (1) It is double chamfered—goes on from either side—is ideal for either hand or hopper feeds. (2) The lock is in the center of the nut—permits fastest starts—allows bolt end to be below or flush with top of nut. (3) Two-Ways are economical; reusable; better looking on your finished product.

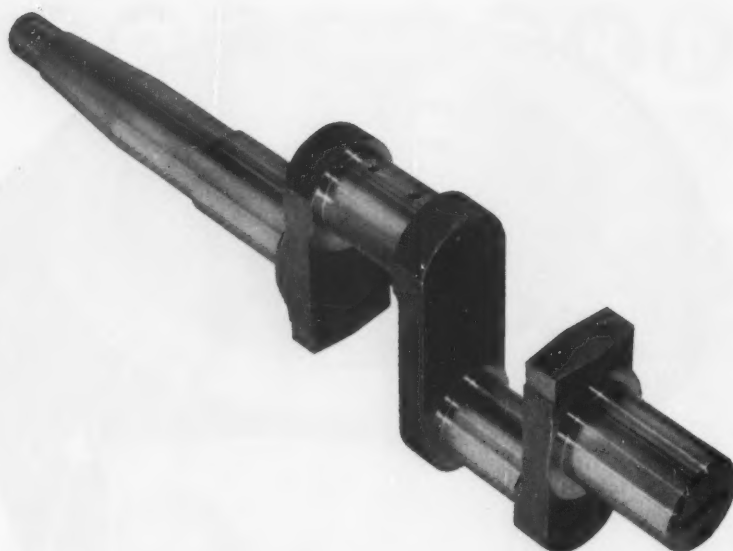


Circle number on reply card for catalog and technical data.

**MACLEAN-FOGG LOCK NUTS**

**MacLean-Fogg Lock Nut Company**  
5535 N. WOLCOTT AVENUE  
CHICAGO 40, ILLINOIS

1926 **35** 1960  
ANNIVERSARY



## RIGIDITY

**A CASE IN POINT**—This seventy pound ductile iron crankshaft is made for compressors manufactured by The Brunner Division of Dunham-Bush, Inc. The increased loads and speeds called for by new compressor design specifications required rigidity and strength beyond the limits of the cast iron alloy shafts formerly used. Ductile iron was chosen because the rigidity, tensile strength, fatigue strength and wear characteristics comfortably exceed operating requirements. A major bonus—the existing pattern equipment could be used for the ductile iron castings, thus saving the high cost of dies needed for steel forgings.

Ductile iron has most of the engineering advantages of steel yet it can be designed with the same flexibility and cast with the same procedures as gray iron. The 120-90-02 grade used in this case has an elastic modulus of about  $24 \times 10^6$  psi, 42,000 psi endurance limit, and 300 BHN. The 120,000 psi tensile strength is double that of the previous crankshaft. Hamilton Foundry regularly casts all grades of ductile iron and high alloy Ductile Ni-Resist.

When new and unusual design problems arise in the selection of metal and the casting of parts, you will find that the skill and integrity of your foundry is your best insurance that specifications—and delivery schedules—will be met.

GRAY IRON • ALLOYED IRON • MEEHANITE® • DUCTILE (NODULAR) IRON • NI-RESIST • DUCTILE NI-RESIST • NI-HARD



# HAMILTON FOUNDRY INC.

1551 LINCOLN AVENUE • HAMILTON, OHIO • TWInbrook 5-7491

Circle 480 on Page 19

### HELPFUL LITERATURE

#### Miniature Gears & Pinions

Hundreds of low-cost, zinc die-cast gear and pinion components and combinations are listed in stock list Bulletin 3001. Typical applications include business machines, clock mechanisms, record players, appliance timers, voting machines, and similar gear train applications involving low torque. Parts can also be molded in Delrin, nylon, and most thermoplastics. 10 pages. Gries Reproducer Corp., 125 Beechwood Ave., New Rochelle, N. Y.

D

Circle 648 on Page 19

#### Speed Reducers

Catalog MR-58 is a complete selection guide for vertical Motoreducers and in-line reducers in eight housing sizes for applications up to 125 hp and output speeds of 9 to 420 rpm. Output speeds of vertical units are field-changeable using any of 16 standard gear sets. Also included are construction and mechanical features, AGMA ratings, service factors, mounting dimensions, and parts list for each reducer. 28 pages. Philadelphia Gear Corp., 3620 "G" St., Philadelphia 34, Pa.

E

Circle 649 on Page 19

#### Torque Converters

A new series of Clark torque converters for off-the-road vehicles or industrial power transmission is available in 14, 15, or 16 in. wheel size and in four power absorption ranges from 400 to 775-lb-ft input. Bulletin FFS-5 shows details and contains complete power curves for each basic model. 4 pages. Clark Equipment Co., Automotive Division, Jackson, Mich.

T

Circle 650 on Page 19

#### Safety Head Assemblies

Part numbers and cross-sectional diagrams for 64 different pressure-head assemblies designed for use with Baker precious-metal rupture discs are given in Catalog 459. The assemblies are available in a range of sizes for straight through, tee, and cross type applications. 4 pages. High Pressure Equipment Co. Inc., Erie, Pa.

F

Circle 651 on Page 19

#### Strain Measurement

Brul & Kjaer "Technical Review" No. 3 describes industrial dynamic strain measurement techniques and procedures for analyzing the spectrum of complex strain signals. These involve measurement of sound, vibration, and strain. 24 pages. B & K Instruments, Inc., 3044 W. 106th St., Cleveland 11, Ohio.

F

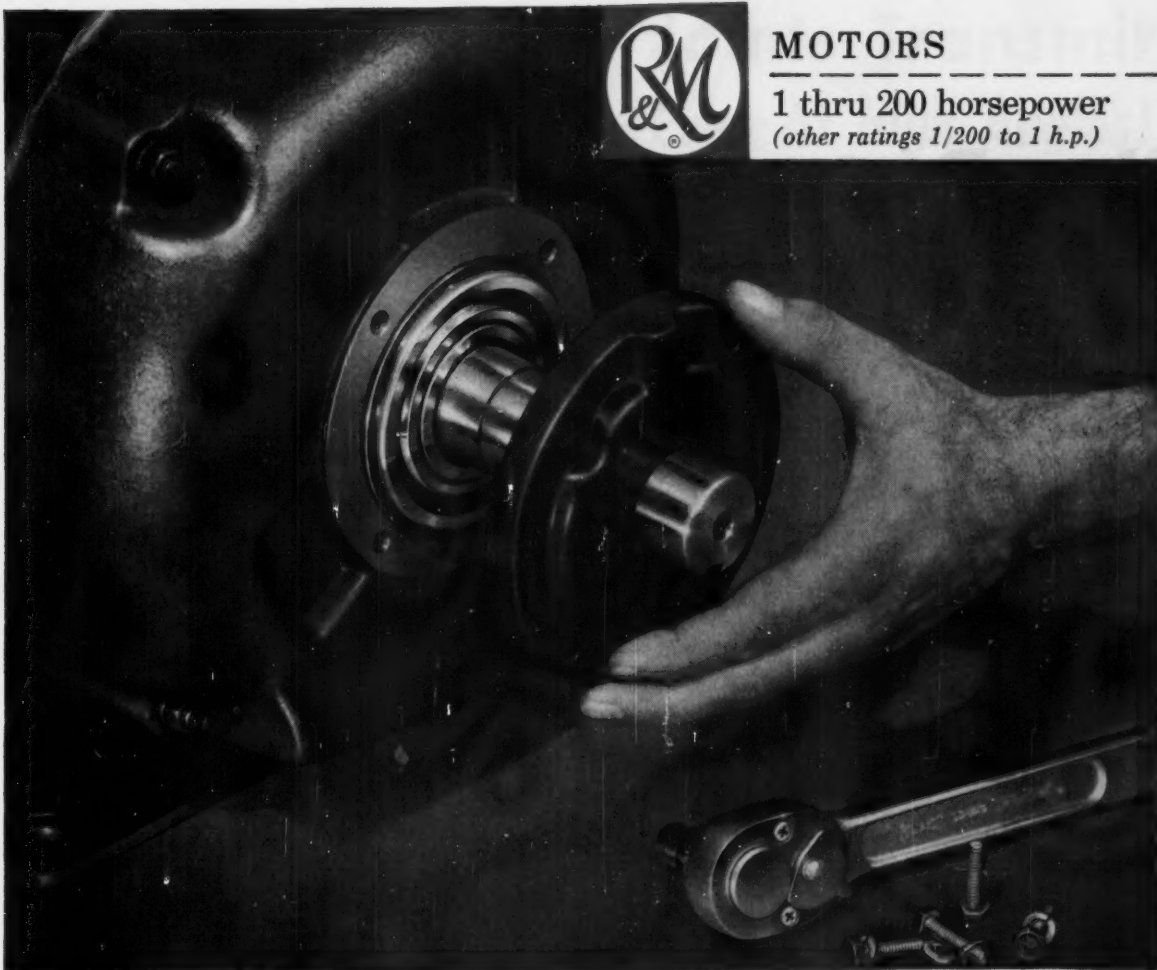
Circle 652 on Page 19

#### Electrolytic Capacitors

Ratings, performance, and dimensions of Type QE computer-grade electrolytic condensers are shown in Bulletin NPJ-110. Size of condensers is a uniform  $4\frac{1}{2}$  in. high with diameters varying to suit requirements of ratings. 4 pages. Aerovox Corp., New Bedford, Mass.

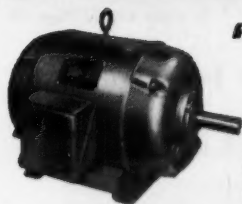
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Circle 653 on Page 19



## MOTORS

1 thru 200 horsepower  
(other ratings 1/200 to 1 h.p.)

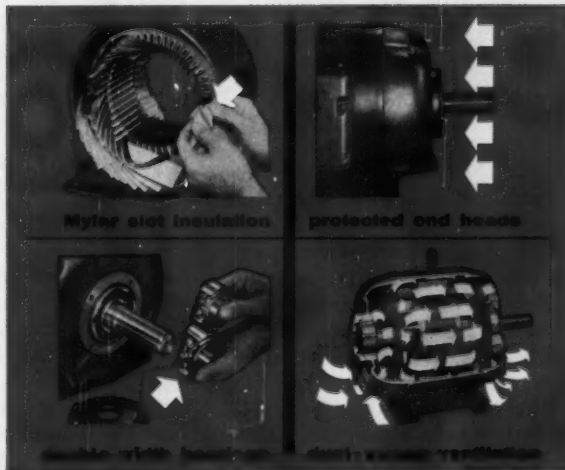


### "On-the-Job" Bearing Inspection and Relubrication are Easy!

ROBBINS & MYERS motor bearings are fully sealed and pre-lubricated to operate for years without attention of any kind. However, when maintenance schedules call for bearing inspection and relubrication at shorter intervals, R&M motors cut downtime and save labor expense by making these inspections easy. The bearing cap on each end head comes off quickly when the four securing bolts are removed. The bearing seal, held in place by removable snap rings, likewise, is easily removed to expose the interior of the bearing.

Easily removable bearing caps are only one of R&M's many desirable design features. Double width bearing races have extra-large grease capacity . . . Mylar® insulation that has 8 times the dielectric strength and 35 times more moisture resistance than ordinary paper insulation . . . end heads offer full-height protection . . . dual-sweep ventilation assures efficient cooling. For details, write today for Bulletin 520 MD

\*DuPont registered trademark



### ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Mogno industrial pumps  
SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

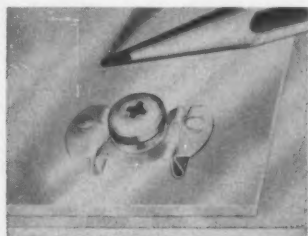
# New Parts and Materials

Use Yellow Card, page 19, to obtain more information

## Quarter-Turn Fasteners

are small size, lightweight

Small dimensions of Lion quarter-turn fasteners save weight and space. Receptacle measures 0.812 x 0.375 in. over-all, is 0.012 in. thick. Retainer and stud are correspondingly proportioned. Six different stud lengths accommodate total material thickness (both sheets) of



0.040 to 0.159 in. The three parts are made of cadmium-plated steel. Grip range is a generous 0.020 in. in each stud length. Stud is swage-nosed. All parts are hardened for long wear. Southco Div., South Chester Corp., Lester, Pa. E

Circle 654 on Page 19

## Tiny Telescoping Joint

lateral motion possible  
in zero-backlash universals

Two preloaded ball splines in tiny universal joints provide lateral travel and a minimum amount of thrust on connected components. Bearing surfaces between burnished sockets and precision balls are preloaded for continuous contact; lubrication is sealed in. This design assures zero backlash for the entire assembly. Body components are Type 303 stainless steel; balls are Type 440 stainless. Standard assemblies have 1/4 in. lateral travel; greater travel on specials. Standard sizes are: 3/16 in. body with 3/32 or 1/8 in. bores, 9/32 in. body with 3/16 in. bore, 3/8 in. body with 1/4 in. bore. Torque



ratings for the three body sizes are 16, 64, and 256 oz-in., respectively. Falcon Machine & Tool Co., 209 Concord Turnpike, Cambridge, Mass. B

Circle 655 on Page 19

## Epoxy-Acrylic Coating

dries in few minutes  
without baking

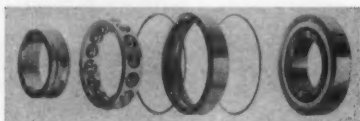
Ep-Ack epoxy acrylic coating comes in a wide range of colors and is available in any degree of gloss from zero to 95. The coating air-dries in a few minutes, the same durability as obtained by baking. Flexibility is excellent, and the coating has outstanding adhesion. The coating will not discolor when subjected to the sun. It resists salt, fog, humidity, acid, and alkalies. It can be used as a primer as well as a finish coat or in combination with other coatings. Technical Service Dept., Industrial Finishes Co., 1119 Land Title Bldg., Broad & Chestnut Streets, Philadelphia 10, Pa. E

Circle 656 on Page 19

## High-Capacity Bearings

have two to six more balls  
than equivalent Conrad bearings

Load capacities from 19 to 55 per cent greater than equivalent-size Conrad bearings are obtainable in HDR radial ball bearings. Or life expectancy can be up to 298 per cent greater for the same load. Bearings are also more rigid, with an

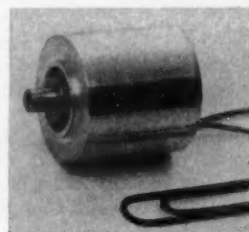


average of 20 per cent less radial deflection. Single fracture in outer ring of the bearing permits spreading to allow assembly of a maximum complement of balls (two to six more than equivalent Conrad bearings). Omission of loading slots permits bearings to carry thrust loads from either direction. One-piece, outer land-riding bronze retainer has high strength, improves internal lubrication, and permits high operating speeds. Offered in ABEC-3 and ABEC-5 precision grades, the new bearings are made in Extremely Light, Extra Light, Light, and Medium series, in metric sizes up to 85 mm OD. Standard material for rings and balls is 52100 steel. Four ranges of internal clearance allow designers a wide variety of operating characteristics. Split Ballbearing, Div. of MPB Inc., Lebanon, N. H. B

Circle 657 on Page 19

## Lightweight Solenoids

operate from unrectified  
400-cycle ac power



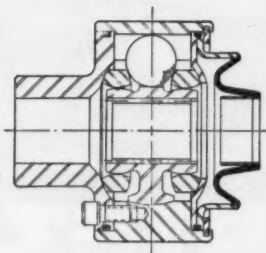
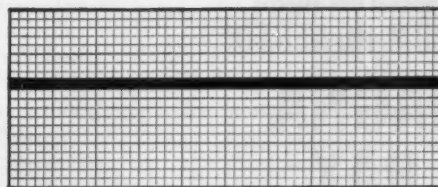
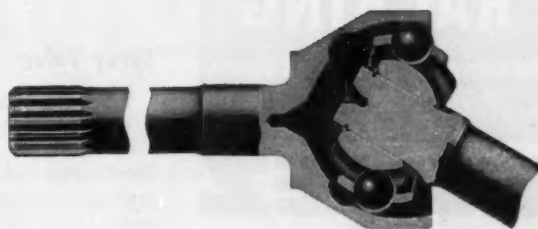
Linear-magnetic actuator operates without rectification from a 400-cycle ac power source. Solenoids may be used singly, or stack-mounted for multiple performance. Available in two sizes, they have externally adjustable stroke length and linear action that may be either push or pull. Smaller Model 175 weighs 1.3 oz and consumes 13 w; larger Model 375 weighs 5.1 oz and uses 40 w. Both operate continu-

# RZEPPA Universal Joints Transmit Torque Smoothly—Even At High Angles!

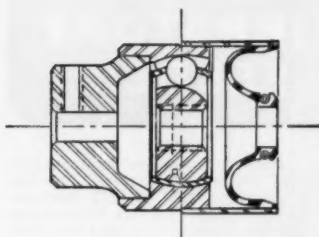
Rzeppa universal joints transmit 100% precision-smooth torque continuously—at angles of 35° and higher! Constant velocity action completely eliminates chatter, roughness and vibration. Size for size, you get longer shaft and bearing life, higher torque capacity with Rzeppa joints than with any other type!

The secret of Rzeppa's uniform power flow is that the driving balls are always in the bisecting plane of the driving and driven shafts. No matter what the shaft angle, torque flows evenly at constant velocity.

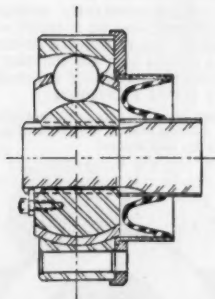
Rzeppa constant velocity joints are available in a wide variety of sizes, styles, angles and speeds. Rzeppa joints have been used successfully in equipment ranging from giant road-building and mining equipment to the most intricate aircraft and missile applications.



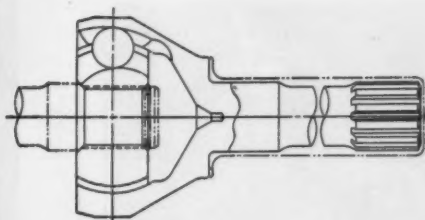
"MX" Type CV Joint ( $\frac{7}{8}$ " to  $3\frac{1}{2}$ " swing diameter) . . . designed primarily for high speeds, low angles . . . blowers • compressors • servo motors • pumps • control devices • frequency converters • missiles • aircraft • dynamotors



"OV" Type CV Joint ( $2\frac{1}{4}$ " maximum swing diameter) . . . designed for smaller applications . . . ordnance • machine tools • servo mechanism • farm equipment • automotive equipment



Disc-Type CV Joint (from  $2\frac{1}{4}$ " to  $16\frac{1}{4}$ " swing diameter) . . . designed for all types of industrial drive applications where constant velocity and trouble-free service are required.



Bell-Type CV Joint ( $15/16$ " to  $2\frac{1}{2}$ " axle shaft diameters) . . . designed for high-angle driving steering axles used in road building machinery • mining machinery • industrial • automotive applications

## WRITE

for this new engineering data folder on the complete line of Rzeppa constant velocity joints. No cost or obligation to you.



Please send my copy of Con-Vel's NEW engineering data folder on CV universal joints.

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## CON-VEL DIVISION

DANA CORPORATION

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Detroit 11, Michigan

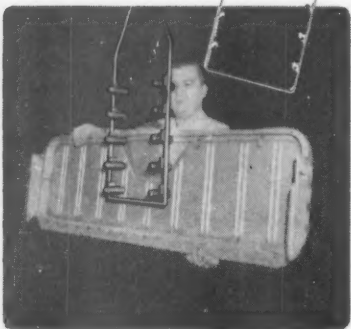
## NEW! FASTER RACKING

for conveying all Sizes and Shapes  
of Stampings, Parts, etc.

# ERIEZ

permanent non-electric  
ERIU<sup>®</sup>-POWERED\*

## MAGNA- RAX



GET INCREASED CONVEYING EFFICIENCY. Magna-Rax magnetic power holds parts firmly in place while being conveyed... loading and unloading is faster... easier! One model will handle hundreds of sizes and shapes of parts... Magna-Rax are ideal for assembly line operations, where parts are conveyed from one point to another. Magnetic strength firmly holds parts while many operations such as tack off, dipping, spray painting, coating, degreasing, washing, inspecting, etc., are being performed... no need for special holes, lips, etc., on the parts as a means of holding.

Ideal for overhead or monorail systems. Rust and corrosion resistant... unaffected by temperatures up to 750°. Available in most any size and shape and with any number of Holding Magnets.

\*Erium—an exclusive, high quality permanent magnetic power source specifically designed and energized by Eriez.

Write for data on this exciting new product.  
Eriez Mfg. Co., 1318A Magnet Drive, Erie, Pa.



Circle 483 on Page 19

### NEW PARTS AND MATERIALS

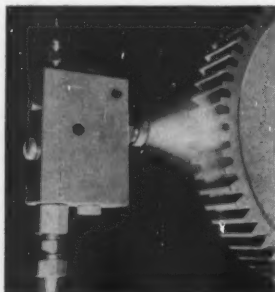
ously from -65 to +450 F. B. H. Hadley Inc., Special Projects Office, 10681 Santa Monica Blvd., Los Angeles 25, Calif. L

Circle 658 on Page 19

### Spray Valve

lubricates gears  
from centralized systems

Gear spray valve for use with centralized lubricating systems requires only 15 to 25 psi air pressure for optimum spray results. It automatically shuts off air when lubricant feed shuts off, resulting in substantial savings in air and lubricant. Valve requires no adjustment for varying lubricant viscosities or temperatures. Oils and all greases suit-



able for pumping may be used. The valve can be used with centralized systems specifically planned for gear lubrication only, or can be used in systems where both gears and bearings are served by the same pump. Flat-pattern (internal mix) or cone-pattern (external mix) spray nozzles are available. Trabon Engineering Corp., 28815 Aurora Rd., Solon, Ohio. F

Circle 659 on Page 19

### Telephone-Type Relay

tested without failure  
for 100-million operations

Type 5 Relay provides unusual dependability; in actual test, it has performed over 100 million operations without mechanical failure. Key to this performance is the use of independent twin contacts. Long, flexible contact fingers of the bifurcated stationary springs allow the twin contacts to operate independently of each other, so that one will close even if the other is blocked. The dc relay is a fast-

# No Other FEEDER Like It!



electro-permanent magnetic

# ERIEZ

## HI-VI VIBRATORY FEEDER

All-new award-winning feeder built on new concepts of design and materials. Provides accurate, controlled feed of bulk materials automatically. Variable feed rate, from ounces to tons. For spreading, sorting, aerating, cooling, proportioning, etc. Feeds all types of bulk materials. Increases production; reduces operating and maintenance cost.

NEW A.C. ELECTRO-PERMANENT MAGNETIC DRIVE PROVIDES GREATER FEEDING CAPACITY • NO RECTIFIER NEEDED • FULLY ENCLOSED POWER ELEMENT PROTECTED AGAINST DUST AND MOISTURE • RUGGED GLASS FIBER SPRINGS REDUCE BREAKAGE • FULLY PROVED IN PLANTS EVERYWHERE.

ALSO AVAILABLE: Economical, specially constructed units for hazardous, dusty locations... fully acceptable by Mill Mutual.

WRITE FOR BIG VIBRATORY FACT FILE  
Eriez Mfg. Co., 131-BB Magnet Dr., Erie, Pa.



Circle 484 on Page 19

# ADJUSTABLE STROKE SAVES TOOLING

Now—put pressure where it's wanted instantly and cheaply—with Mead's powerful midget air cylinders (1" bore, single-acting, spring return). Stroke is adjustable to exact length required, even after components are locked in place. Use them singly or in groups to move, hold, press or eject small work pieces; to close and open large jigs, forms, fixtures. Actually they will replace human fingers and mechanical clamps in innumerable routine jobs.



## NEW MIDGET AIR CLAMPS

(SPRING RETURN AIR CYLINDERS)

**NEW! SAVES TIME!** These outstanding Air Clamp cylinders with adjustable strokes variable from  $\frac{1}{8}$ " to 3" can be "tuned" to exact length wanted even *after* setup is made! This feature alone saves hours of time designing, laying out special jigs, fixtures. **NEW! SAVES AIR!** You can conserve air in large fixtures (where dozens or hundreds of Midget Air Clamp cylinders are used) by using "just enough—no more" stroke. The shorter the stroke, the faster the cycle. **NEW! SAVE SPACE & MONEY!** The cylinder "nose" telescopes into barrel reducing stroke and overall length. All this at prices so low you can almost *forget* their modest first-cost. But you'll *remember* the countless man-hours saved—the lessened fatigue of your workers at monotonous jobs—the improved quality and accuracy of their work!



WRITE FACTORY  
OR NEAREST MEAD  
REPRESENTATIVE  
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of Thomas' Register for  
address, phone number,  
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**MEAD**  
SPECIALTIES CO.

4114 N. KNOX AVE., DEPT. MD-20, CHICAGO 41, ILLINOIS  
PATHFINDER IN AIR POWER AUTOMATION

## THE NATIONAL SCENE



### "Inspect the product-improving, cost-cutting metal-like properties of new DELRIN®"

National can now furnish extrusions or fabricated parts of this remarkable new Du Pont thermoplastic

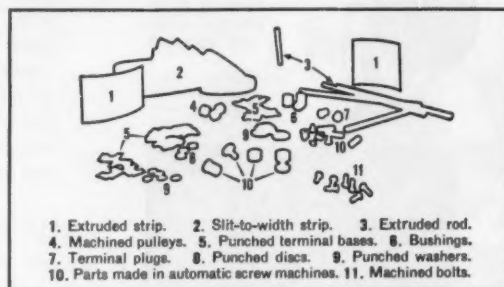
If you have not yet evaluated this exciting new material you will want to. Exhaustive tests show that "Delrin" can compete on a cost and performance basis with parts made of many metals, rubber, glass or wood. It may be the *one best material* to solve a current problem for you.

In adding "Delrin" to its family of thermoplastics, National continues the policy of offering the designer industry's widest selection of basic materials—over 100 types and grades. "Delrin" is available in extruded rod, strip, and special shapes, or in precision fabricated parts to your design. You can depend on National's production experience for sound help on "Delrin" applications.

Sizes now available include: rod— $\frac{1}{4}$ " to 2" diameter; strip—.020" through .093" thick, up to 7" wide.

Special extruded shapes available upon request. Fabricated "Delrin" parts now being furnished National's customers indicate broad application wherever strength, rigidity and dimensional stability are important.

For specific information, prices and personal assistance on the use of "Delrin"—or any of the more than 100 National materials—write National Vulcanized Fibre Co., Dept. G-2, Wilmington, Delaware. Or contact your nearby National Sales Office.



1. Extruded strip. 2. Slit-to-width strip. 3. Extruded rod.
4. Machined pulleys. 5. Punched terminal bases. 6. Bushings.
7. Terminal plugs. 8. Punched discs. 9. Punched washers.
10. Parts made in automatic screw machines. 11. Machined bolts.



## CHOOSE FROM THESE MATERIALS...

**Vulcanized Fibre:** 10 standard grades; many special grades.

**PHENOLITE® Laminated Plastic:** over 80 standard and modified grades; paper, cotton fabric, nylon, asbestos, glass fabric, cotton and glass mat bases; phenolic, melamine, polyester, epoxy, teflon or silicone resins.

**PEERLESS Electrical Insulation:** coil, strip, corrugated.

**Extruded Nylon, "Delrin", "Penton":** rod, strip, tubing, special shapes.

**Polyester Glass Mat:** 4 standard sheet grades; custom molded shapes.

**PHENOLITE Copper-Clad Laminates:** 10 standard grades.

**Combination Materials:** Rubber-PHENOLITE; Rubber-Fibre; Wood-Fibre; Metal-Fibre; Asbestos-Fibre; PEERLESS-PHENOLITE.

## BACKED BY THESE SERVICES...

Field Application Assistance  
Complete Fabricated Parts Service  
Stock Program for Immediate Shipment

## BY CALLING THESE OFFICES...

Baltimore	Valley 3-0393
Boston	TWinbrook 4-3500
Chicago	AUstin 7-1935
Cincinnati	GArdfield 1-0632
Cleveland	ERiewick 1-0240
Dallas	DAvis 4-4386
Denver	MAin 3-2077
Detroit	UNiversity 3-3632
Griffin, Ga.	8-1308
Indianapolis	WAInut 3-6381
Los Angeles	RAymond 3-0291
Milwaukee	BRoadway 6-6995
New Haven	LOCust 2-3594
Newark	MITchell 2-6090
New York	CORTlandt 7-3895
Philadelphia	SHerwood 8-0760
Pittsburgh	FAirfax 1-3939
Rochester	HIllside 5-0900
St. Louis	PArkview 5-9577
St. Petersburg	5-5505
San Francisco	DAvenport 6-4667
Seattle	MElrose 2-7298
Wilmington	OLympia 5-6371

### IN CANADA:

National Fibre Co. of Canada, Ltd.  
Toronto LENnox 2-3303  
Montreal AVenue 8-7536



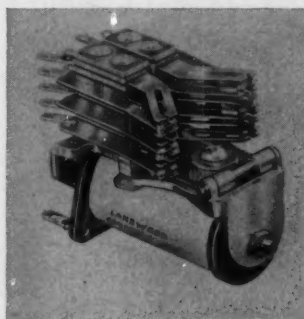
**NATIONAL  
VULCANIZED FIBRE CO.**

WILMINGTON 99, DELAWARE

In Canada:

NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 5, Ontario

## NEW PARTS AND MATERIALS



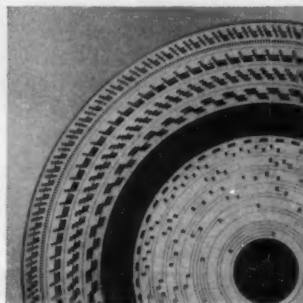
operating, fast-releasing type with a design that provides large bearing surface for the hinge-type armature. The pivot pin turns in a cylinder of a different metal which is the full width of the heel-piece. Twin contact points of Code 24 (palladium) contact material have a combined rated current carrying capacity of 4 amp, 150 w. Operating speed is 1 to 2 milliseconds min. Coil is single or double-wound and can be provided with a choice of time-delay features. Lakewood Controls Corp., Industrial Road, Crystal Lake, Ill.

Circle 660 on Page 19

## Shaft-Position Encoder

binary-decimal unit gives three-digit count per turn

Accurate to one part in 1000 per single turn of input shaft, ADC-ST3-BCD encoder (disc only shown) is a 6-in. diam analog-to-digital converter. It provides three decimal digits (counts to 999) in binary-coded decimal for each revolution of input shaft. Other models include a 10,000-count, 10-turn encoder, a 100,000-count, 100-turn encoder, and a 1-million-count, 1000-turn encoder. Particular application is for film and map readers, machine tools, or where decimal parts of an inch are of primary impor-



put **HEINZE** in your designs



MAN!  
these  
**HEINZE D2 BLOWERS**  
are REAL COOL

Like wow! Heinze D2 Blowers, with durable plastic housings, are ideal for circulation of air, for cooling electronic components and equipment, and for cooling operations in vending machines, laboratories and similar applications.

Powered by the exceptionally long-lived Type D 2-pole shaded pole induction motor, single blower unit delivers 10 cfm (free air), double unit 20 cfm, at 3100 rpm. Rated for 115 V, AC, 60 cycles, blowers are also available for 50 cycle operation. CW or CWW rotation.

Standard units are available from stock for immediate delivery. Send coupon for complete technical data.

SEND COUPON FOR NEW CATALOG



**ELECTRIC COMPANY**

685 Lawrence St.  
Lowell, Mass.

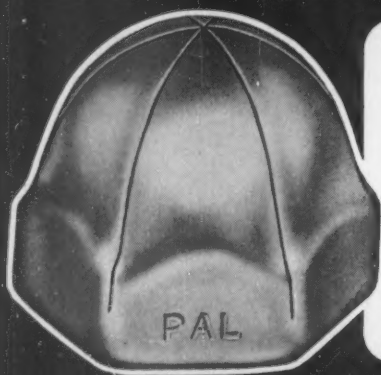
Sub-Fractional Horsepower Motors and Blowers

Heinze Electric Company, Dep't D  
685 Lawrence St., Lowell, Mass.  
Please send literature and prices on the entire line of  
Heinze Blowers.

Name & Title.....  
Company.....  
Street & No.....  
City & State.....

Circle 487 on Page 19

# Cover exposed ends of screws, rods, studs, wire with **ACORN PALNUT® FASTENERS**



- Reduce assembly parts, operations, time and cost
- Provide vibration-proof assemblies
- Low in cost
- Protect against scratching
- Add pleasing appearance.

## 3 TYPES AVAILABLE to meet design needs

### 1 ACORNS that turn on screw threads



#### ACORN PALNUT LOCK NUTS

Attractive spring steel lock nuts apply fast with hand or power tools. Save weight and cost, stay tight in service. Full acorn and semi-acorn types. Many sizes and finishes, #6-32 thru 1/2"-16.

### 2 ACORNS that push on plain rod



#### ACORN PUSHNUTS®

Simply push on un-threaded rod or wire for tight assemblies. Strong spring steel grip. Save threading, drilling, grooving, cotter pins. Closed and open end types. Sizes for .120" to .312" dia. rod in choice of finishes.

### 3 ACORNS that make their own threads



#### ACORN PALNUT SELF-THREADING NUTS

Save cost of threading. Make their own threads while tightening on plain rods, studs or wire. Fast assembly with standard tools. Vibration-proof. Removable and reusable. Sizes for 1/8" and 3/16" dia.

WRITE for free samples and data. State type, size and application.



#### THE PALNUT COMPANY

Division of UNITED-CARR Fastener Corp.

75 Glen Road, Mountainside, N. J.

Canada: P. L. Robertson Mfg. Co., Ltd., Milton, Ont.

LOCK NUTS and FASTENERS

#### NEW PARTS AND MATERIALS

tance. Features are internal self-selecting V-brush logic for unambiguous readings, long life, and a high degree of reliability. Applicable MIL specs are adequately met. Norden Div., United Aircraft Corp., Wiley Street, Milford, Conn. B

Circle 661 on Page 19

#### Wound-Wire Metal

filters corrosive fluids  
at temperatures to 400 F

Poroloy CS wound-wire porous metal is available in hollow cylinders or cones. Cylinders are cut once axially, opened and flattened for forming special shapes. Material is designed for mildly corrosive conditions and temperatures up to 400 F. Wound wires are bonded with silver or copper braze at all contact points.



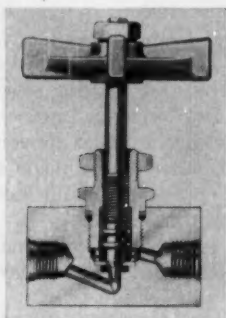
Electroless nickel plating can be added for somewhat higher corrosion resistance. Filter units can be made from almost any metal that can be drawn into fine wire. Typical metals include: Carbon steel, 400-series stainless steel, and other low-alloy stainless steels. Material can be stamped, punched, spun, swaged, pleated, silver soldered, and welded. As few as four layers of wound wire may be used or as many as 30. Pore sizes can range from 2 to 1000 microns or more. Bendix Filter Div., Bendix Aviation Corp., 434 W. 12 Mile Rd., Madison Heights, Mich. T

Circle 662 on Page 19

#### Soft-Seal Needle Valve

is bubble-tight to 6000 psi

For either gas or liquid, "bubble-tight" needle valve has nylon seat. Safety factor of 4 is assured. All internal parts may be removed and serviced without removing the valve



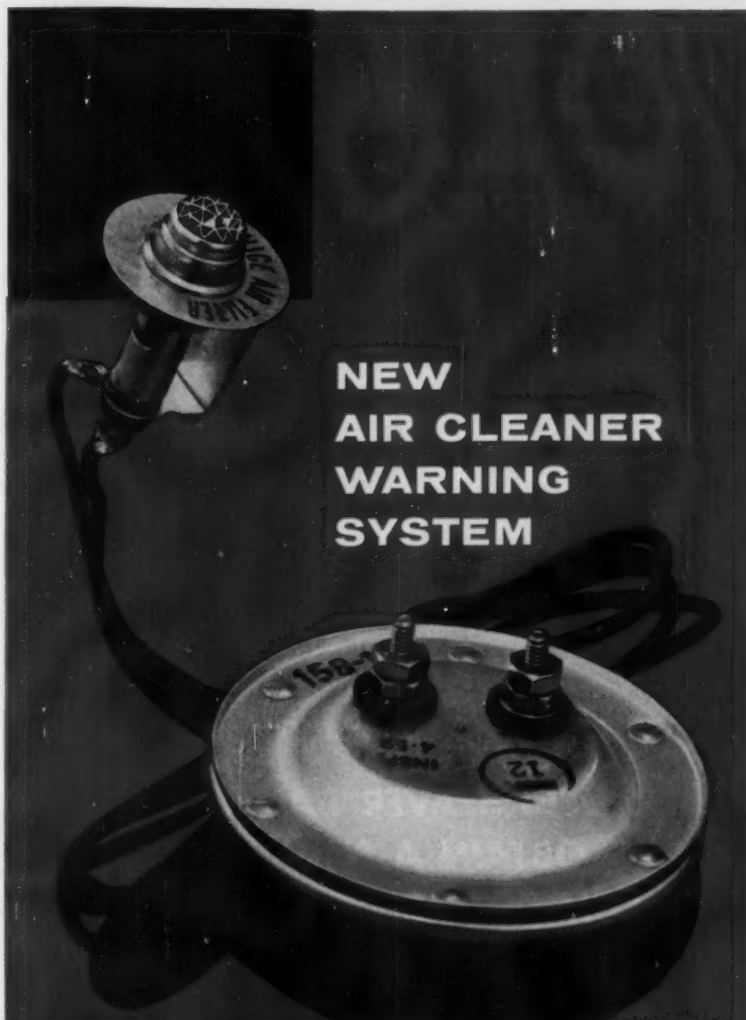
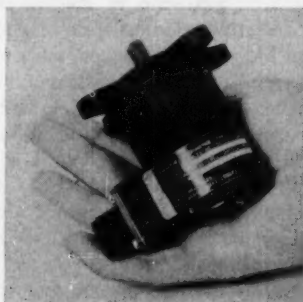
from the line. Valve is designed for mounting on panel up to 1/4 in. thick. Nylon sealing seat is protected from abrasion by a metal retainer. All metal parts are stainless steel, except the handle, which is aluminum alloy. Synthetic-rubber O-ring seals are protected by Teflon back-up rings. The stem has 40-pitch thread for fine adjustment and ease of turning under high pressure. Port threadings are internal straight (AND10050) gasket seal in sizes 1/4, 3/8, 1/2, and 3/4 in. OD, and U. S. Bureau of Standards high-pressure tube, sizes 3/8 and 9/16 in. OD. Operating temperatures range from -65 to +160 F with higher available on special order. Republic Mfg. Co., 15655 Brookpark Rd., Cleveland 35, O. F

Circle 663 on Page 19

### Tachometer-Generator

small-size model  
for high temperatures

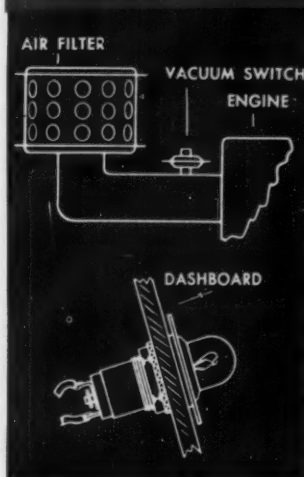
Miniature tachometer generator, designed and tested under MIL-G-26611, is smaller in size than previous models. A two-pole three-phase Y-connected stator and the permanent-magnet rotor furnish alternating three-phase output power with frequency proportional to rotor velocity. Permanent-magnet generator is capable of 14 w output at



## NEW AIR CLEANER WARNING SYSTEM

another fine product by

# McQUAY-NORRIS



System consists of sensitive vacuum switch and dashboard warning light. Can be mounted in any position on the filter with 1/8" male threaded pipe boss. Operates in all temperatures up to 250° F. and can be adjusted within vacuum range 5 to 30 inches water. For both carbureted and non-carbureted engines.



Your inquiries are invited!

McQUAY-NORRIS MANUFACTURING CO.  
ELECTRIC PRODUCTS DIVISION  
3260 Brannon Ave., St. Louis 39, Missouri

50 YEARS IN THE MANUFACTURE OF PRECISION PRODUCTS

# Last Word In TAPE READING NUMERICAL CONTROL!



PRATT & WHITNEY NUMERIC-KELLER

**IT USES BEAVER BALL SCREWS  
TO OBTAIN A NEW  
HIGH DEGREE OF EFFICIENCY  
IN 3 DIMENSIONAL MILLING**

This new machine tool cuts production lead time costs as much as 75%, automatically detects errors and compensates, permits tool change without loss of synchronization and offers many other features.

Table travel is 36" horizontal, 12" traverse, vertical slide moves 22"—and all movements are precision actuated by Beaver Ball Screws, first choice of machine tool designers.

Can our engineers help you obtain

- (1) greater accuracy in positioning
- (2) minimum break-away friction
- (3) greater system stiffness

Beaver engineers are ready to work with you on your actuating problem.

**Beaver  
Precision  
Products  
INC.**  
CLAWSON, MICH.

## NEW PARTS AND MATERIALS

4200 rpm; various outputs may be specified. Generator is built into a black anodized diecast housing. Magnet is cast on the rotor shaft for added strength, and oversize ball bearings are used for long life. Modifications can be made to suit specific applications. Unit illustrated is approximately 2½ in. long; weight is 12.8 oz. Globe Industries Inc., 1784 Stanley Ave., Dayton 4, Ohio. G

Circle 664 on Page 19

## Hydraulic Motors and Pumps for 3000-psi pressures

Hydraulic motors and fixed-displacement pumps provide exceptional life throughout temperature range of -65 to +275 F. Both motors (Series 63000) and pumps (Series 61000) are rated for 3000-psi system pressures. Units are for



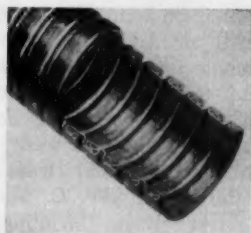
use with MIL-H-5606, MIL-L-7808, Orinite, Skydrol, and other AN-approved hydraulic fluids. Cornelius Co., 557 39th Ave. N.E., Minneapolis 21, Minn. H

Circle 665 on Page 19

## Flexible Pressure Hose

hot or cold liquids  
carried in metal hose

Meeting Government specifications, including salt spray and salt immersion tests, Interlox Pressure Hose BD-15 is available in coated galvanized steel, stainless steel, or phosphor bronze (for reduced magnetic permeability and to resist seasonal weather cracking). It is suitable for conveying hot or cold liquids under pressure. Packed with Underwriters'-approved asbestos yarn, the flexible metal hose can be used for remote valve controls, steam lines, pressure sprayers, hot tar or asphalt spraying, and torque-tool



shafting. It is available in ID sizes of  $\frac{1}{2}$ ,  $\frac{3}{4}$ , 1,  $1\frac{1}{4}$ ,  $1\frac{1}{2}$ ,  $1\frac{3}{4}$ , 2,  $2\frac{1}{2}$ , or 3 in. International Metal Hose Co., Ashford Avenue, Bellevue, Ohio. F

Circle 666 on Page 19

### Asbestos Fabric

impregnated with aluminum;  
coated with neoprene

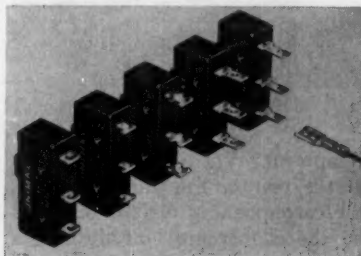
All-purpose, leakproof Neo-Bestos fabric, is strong and lightweight. Manufactured of Underwriters' grade asbestos and coated with neoprene, the fabric is impregnated with aluminum for greater strength and for neater looking installations on flexible ductwork. Fabric offers the superior heat resistance of asbestos and airtight qualities of neoprene. Cost is only a fraction more than standard canvas. Elgen Mfg. Corp., 32-49 Gale Ave., Long Island City, N. Y. D

Circle 667 on Page 19

### Snap-Acting Switches

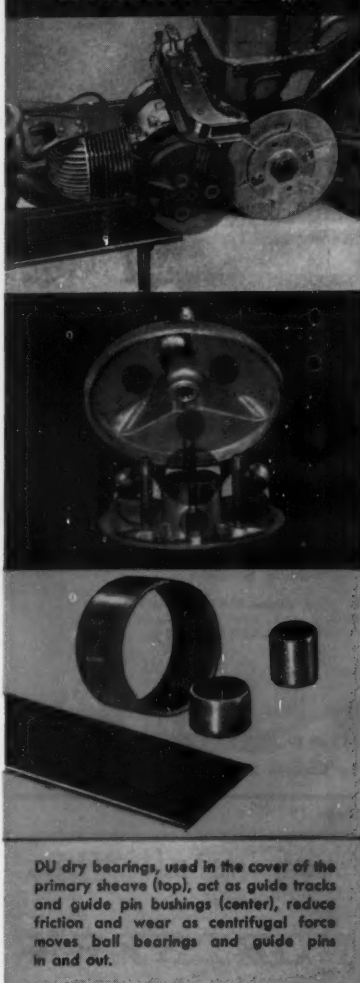
now available in  
five terminal styles

Subminiature precision snap-acting switches are now provided with three kinds of solder-lug terminals, as well as snap-on terminals and terminals for printed-circuit wiring. Solder-lug terminals include the short type with hole for wires up to No. 18, a single-turret lug, and a double-turret lug. The turret lugs are flat so that wires do not slip when wrapped around the ter-



February 4, 1960

### EXAMPLE #1



DU dry bearings, used in the cover of the primary sheave (top), act as guide tracks and guide pin bushings (center), reduce friction and wear as centrifugal force moves ball bearings and guide pins in and out.

## NEW GLACIER DU\* DRY BEARINGS

greatly improve  
transmission design  
of Harley-Davidson  
"Topper"

Used at vital locations in the transmission assembly, DU dry bearings reduce friction and wear to the absolute minimum on the latest addition to Harley-Davidson's fine motor scooter line. DU dry bearings solve another problem, too—the accumulation of dirt and grime in the transmission lubrication. DU material requires no lubrication whatsoever, and will last many times longer than other dry bearings.

DU metal is an ideal bearing material. It withstands much higher velocities, runs much cooler at lower speeds than other unlubricated bearings... has a compressive strength of 51,000 p.s.i. DU metal is applied without the need for temperature-limiting adhesives... will withstand from  $-328^{\circ}\text{F}$  to  $+536^{\circ}\text{F}$ .

Apply DU material to appliances, automobiles, aircraft, farm and industrial machinery, office equipment. Standard bushings and thrust washers stocked for  $\frac{3}{8}$ " to 2" shafts;

# GARLOCK

strip available for special fabrication. Find out more from your bearing manufacturer, or write for engineering catalog DU-458. Special Products Dept., United States Gasket Company, Plastics Division of The Garlock Packing Company, Camden 1, New Jersey.

\*Trademark, Glacier  
Metal Company Ltd.



Circle 491 on Page 19

177

# GRC FASTENERS

- ☐ REDUCE COSTS
- ☐ SIMPLIFY ASSEMBLY
- ☐ IMPROVE APPEARANCE with

DIE CAST ZINC ALLOY  
& MOLDED NYLON

## CAP NUTS



CLOSED END



OPEN END



HIGH TYPE



WASHER BASE

Distinctive, accurately dimensioned, smoothly finished, completely free of tool marks and cut-off burrs.  $\frac{1}{4}$ " to  $1\frac{1}{2}$ " hex #4-36 to  $7/16$ "-20 threads

Write today for new detailed catalog.

- Uniformly accurate
- High in quality
- Low in cost
- Wide range of stock styles, types, sizes and threads

Produced in one high speed automatic operation, GRC's exclusive methods assure uniformity, smooth, rustproof & corrosion resistant surfaces and the lowest possible cost. New kinds of fasteners never before available... modifications in stock fasteners for specified use... infinite variety in styles, types and sizes, have been made possible by GRC's special automatic die casting and molding machines.

Write, wire, phone **RIGHT NOW** for prices and your copy of GRC's NEW DETAILED CATALOG

World's Foremost  
Producer of  
Small Die Castings



**GRIE**

**GRIE REPRODUCER CORP.**

32 Second St., New Rochelle, N. Y. • New Rochelle 3-8600

DIE CAST  
ZINC ALLOY



Wing Nuts



Cap Nuts



Thumb Nuts



Thumb & Wing Screws

MOLDED  
NYLON



Screws



Hex Nuts



Washers



Screw Insulators

## NEW PARTS AND MATERIALS

minimal. Snap-on terminals fit miniature AMP or Ark-Les Quick-Connect female terminals. The printed-circuit terminals are designed to fit  $3/32$ -in. slots in wiring boards and have holes to allow ready connection of component leads beneath the board. W. L. Maxson Corp., Ives Road, Wallingford, Conn. B

Circle 668 on Page 19

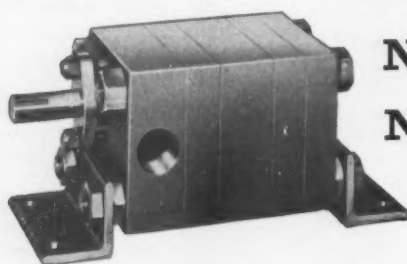
## Open-Cell Foam

is heat-sealable,  
low-density vinyl

Open-cell polyvinyl-chloride foam, called Hi-Vi, is low-density type for deep cushioning. Produced by a continuous chemically blown process, the foamed vinyl sheet is consistently uniform in quality. Continuous lengths up to 48-in. wide, in thicknesses as small as  $1/8$  in., are available, as well as wide range of density specifications. Readily laminated to cloth, foam can be compressed and heat sealed. It is not subject to aging deterioration, and offers resistance varying from good to excellent to acids, alkalis, grease and oils, high humidity, sunlight, water, and air. Highside Foam Products Inc., 10 Colfax Ave., Clifton, N. J. D

Circle 669 on Page 19

Proven in thousands of installations



## NORTHERN NITRALLOY PUMPS

Northern Nitralloy Pumps are noted for their ability to handle difficult pumping assignments. They're able to do so because they are built to tolerances of extreme accuracy from a variety of metals. Rugged design plus precision construction equals years of good service.

Pump sections and parts are interchangeable and can be made from Nitralloy, ni resist, cast iron, steel, stainless steel, bronze, aluminum and other metals. This permits designing pumps for virtually any application.

Northern Pumps are available in capacities from  $1/4$  to 146 gpm at pressures up to 2,000 psi. For free catalog and engineering data, write today.

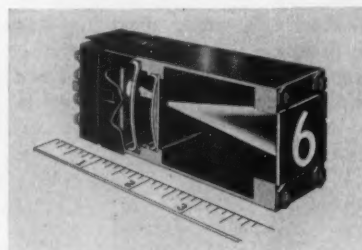
## Northern Ordnance Incorporated

Subsidiary of NORTHERN PUMP COMPANY  
Minneapolis 21, Minnesota

## Miniature Readout

projects  $5/8$ -in. characters  
on front viewing screen

Series 120000 miniaturized digital readout is designed for use with digital computers, control equipment, instruments, production and inventory control equipment, and other electronic or electrical test



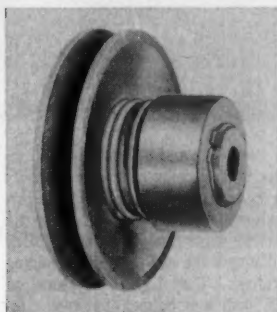
equipment. When one of 12 lamps at the rear of the unit is lighted, the corresponding digit is projected on the condensing lens through a

projection lens onto the viewing screen at the front. Light sources are subminiature lamps, Nos. 327, 328, or 330. Power is 6 to 28 v. Quick disconnect at the rear is for lamp replacement. Character displayed is  $\frac{5}{8}$  in. high. Case is aluminum, weighing approximately 4 oz. Dimensions:  $3\frac{7}{8}$  in. long overall, 1 in. wide, and  $1\frac{5}{16}$  in. high. Industrial Electronic Engineers Inc., 5528 Vineland Ave., North Hollywood, Calif. L

Circle 670 on Page 19

### Variable-Speed Pulleys

low-cost units for  
2.8 to 1 speed ratios



Series consists of five sizes from fractional to 1 hp with speed ratios up to 2.8 to 1. Pulleys are as easy to install as an ordinary V-belt drive, yet permit accurate adjustment over a wide range of speeds. Construction features include curved pulley faces for full belt contact, high ratio for small face diameter, positive lubrication, and compact, lightweight construction. Lovejoy Flexible Coupling Co., 4882 W. Lake St., Chicago 44, Ill. J

Circle 671 on Page 19

### Small Pumps

deliveries range from  
metering flow to 1200 gph

Small, special-application pumps are available in 24 catalogued models with deliveries from metering flow to 1200 gph and discharge heads to 300 psi. Stainless-steel helical-screw rotor turns within a fixed rubber stator of special shape. Cavities formed between the rotor and the stator move toward the discharge end of the pump, carrying the material being handled. "Progressing cavity" principle provides positive

## GENERAL INDUSTRIES

# Smooth Power

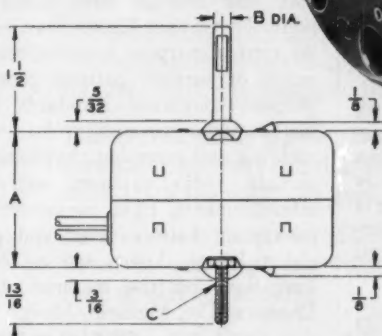
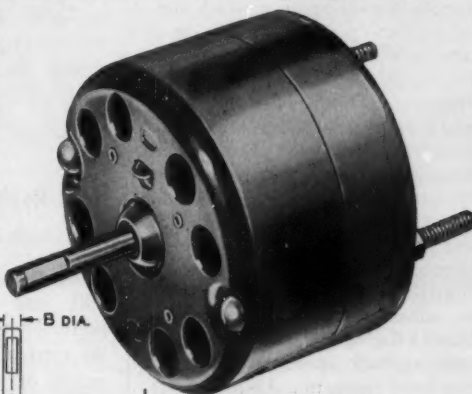
## AC MOTORS

1/1800 H. P. TO 1/36 H. P.

## ADVANCED MOTOR DESIGNS

that meet the demands of the most exacting requirements

Nearly half a century of design and manufacturing experience in the small motor field enables G. I. to offer the most advanced engineering features. This, together with top-notch production know-how and latest manufacturing facilities assure you quality, dependability and economy so necessary to the success of your products.



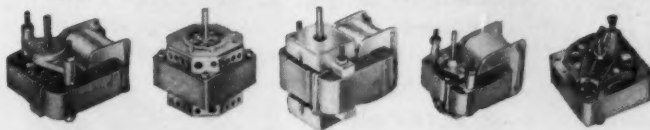
### MODEL-B FOUR POLE, FOUR-COIL SHADED POLE MOTOR

Designed for long life and dynamically balanced for extremely quiet operation. Self aligning, self lubricating bronze bearings, baked, varnish-impregnated windings, ample oil reservoir located for easy lubrication. Smooth, quiet — field proven!

MODEL	HP 1500 RPM	Locked Torque in./oz.	Max. Torque in./oz.	Free Speed RPM	Amps 1500 RPM	Watts 1500 RPM	A	B	C	Wt. Lbs.
B-5-CW B-5-CCW	1/80	3.5	11	1735	.7	53	1 $\frac{1}{8}$ "	$\frac{1}{4}$ "	8-32	2.0
B-8-CW B-8-CCW	1/50	4.0	14	1750	.85	63	2 $\frac{1}{8}$ "	$\frac{1}{4}$ "	10-32	2.7
B-10-CW B-10-CCW	1/40	4.7	18	1750	.95	72	2 $\frac{3}{8}$ "	$\frac{3}{8}$ "	10-32	3.1
B-12-CW B-12-CCW	1/35	4.7	20	1760	1.05	77	2 $\frac{3}{8}$ "	$\frac{3}{8}$ "	10-32	3.4

Above base on fan application with air stream flowing over motor, without air flow derating necessary.

### Designs to Meet the Needs of a Wide Range of Applications



Write today for catalog sheet and quantity-price quotations.



## THE GENERAL INDUSTRIES CO.

DEPT. GK • ELYRIA, OHIO



### Eastman 910 Adhesive solves another production bottleneck

ASCOP Division of Electro-Mechanical Research, Inc., Princeton, N. J., makes an unique digital encoder which converts any shaft position directly into a binary code output. Operating up to 10,000 r.p.m., the tiny instrument is a masterpiece of compact design.

Space limitations require a flush connection between a vinyl plastic sleeve containing the output wires and an aluminum cover plate. Eastman 910 Adhesive plus imaginative thinking solved the problem.

In production, the end of the sleeve is inserted through a hole in the cover plate, adhesive is applied around the hole and a flaring tool forces the end of the tubing back against the plate. A strong bond forms in 2-3 minutes.

Eastman 910 Adhesive is making possible faster, more economical assembly line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?

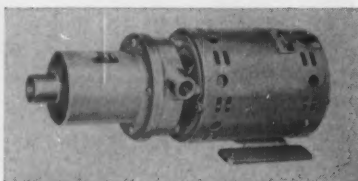


Bonds Almost Instantly  
...Without Heat,  
Pressure or Catalyst

For a trial quantity (1/2-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9102 Dean Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. M-2, Kingsport, Tenn. (Not for drug use) See Sweet's 1960 Prod. Des. File, 7/E

Circle 495 on Page 19

### NEW PARTS AND MATERIALS



displacement, low internal turbulence, and continuous, uniform flow suitable for metering purposes. A broad range of materials can be handled, from water-like liquids to heavy, abrasive slurries, and substances containing relatively large particles in suspension. Pumps have good suction lift and excellent air-pumping characteristics. They are available either with or without direct-connected motors. Moyno Pump Div., Robbins & Myers Inc., Springfield, Ohio. G

Circle 672 on Page 19

### Heat-Resistant Polystyrene is tough and moldable

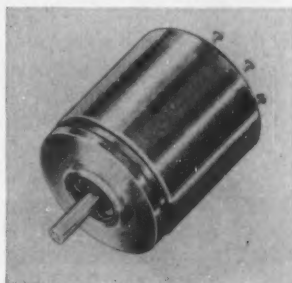
General-purpose polystyrene, Styron 690, has average heat distortion point 20 per cent higher than regular general-purpose formulations. It meets or exceeds current general-purpose toughness standards and has superior properties for both molding and extrusion. Applications include radio cabinets, extruded monofilaments, rigid containers for packaging, battery cases, and television lenses. There are no color limitations on the material. Dow Chemical Co., Midland, Mich. T

Circle 673 on Page 19

### Miniature Generator

variable-frequency type has two-phase ac output

Type 3200 variable-frequency generator is a miniature permanent-magnet type which provides a two-



"the  
HITCHINER  
way..."



saves 35  
MACHINING  
OPERATIONS  
with  
INVESTMENT CASTING

This barrel of a .22 caliber target revolver is now being cast by Hitchiner's new ceramic shell process. This new investment casting technique provides sufficient close tolerances and finishes to eliminate the need for 35 machining operations. Gun barrel tolerance of 0.006 inch was normal, but plus over minus 0.001 inch was maintained on certain areas. Only external finishing needed was partial polishing.

These savings have allowed the manufacturer of this revolver to sell it for considerably less than a similar previous model.

Through investment casting, parts can be designed for function and maximum operating efficiency with the widest selection of alloys from which to choose. This freedom from manufacturing problems can result in more flexibility in design and less waste in production.

Send us a sample or blueprint and check your specific problem with our "engineered quotation" — no obligation, of course.

Find out how our new ceramic shell technique can possibly benefit you. Send for our free, new revised brochure explaining investment castings.



**HITCHINER**  
MANUFACTURING COMPANY INC.  
MILFORD 37, NEW HAMPSHIRE

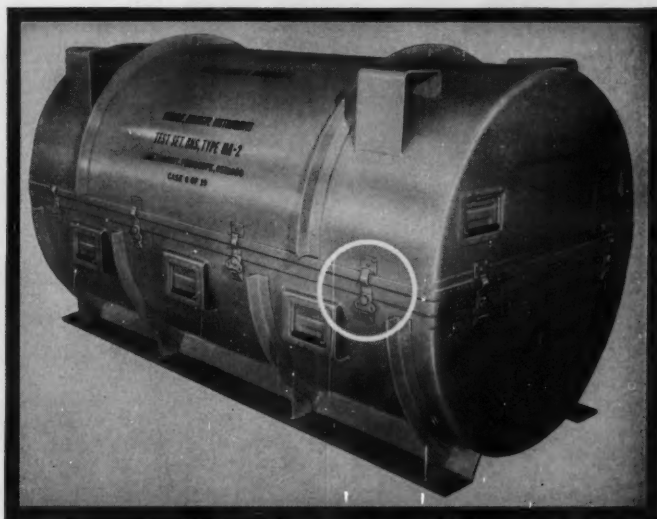
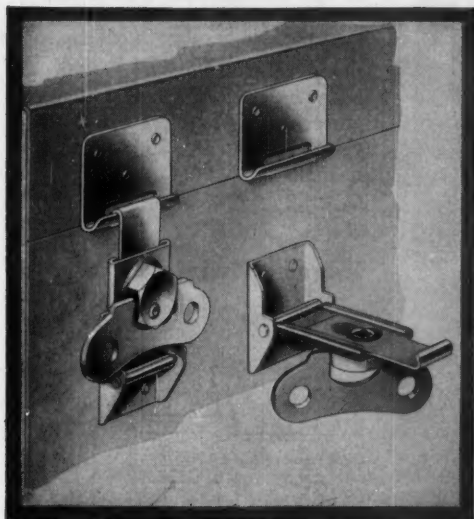
Coast to Coast Engineering Representatives

Circle 496 on Page 19

*Note—Commercial and Military Packaging Engineers:*

# Rugged **LINK-LOCK**

**...your best answer to exacting closure problems**



*Photograph courtesy of Craig Systems, Inc.*

*LINK-LOCK provides  
pressure-tight closure  
on this rigidly specified  
equipment container*

Simmons LINK-LOCK provides quick opening and closing as well as impact-resistant dependability on transit cases manufactured by Craig Systems, Inc., Lawrence, Mass.

The cylindrical Craig container above is gasketed and pressure-tight, and contains delicate electronic equipment. Twelve LINK-LOCK fasteners are used on this model.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

- Impact and shock resistant (positive-locking).
- High closing pressure with light operating torque.....insures pressure-tight seals where required.
- Available in 3 sizes, for heavy, medium, and light duty.
- Compact design...lies flat against case even when unlocked.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design...can be varied to suit different conditions.

Also available: Spring-Loaded LINK-LOCK. Ideal for the less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.



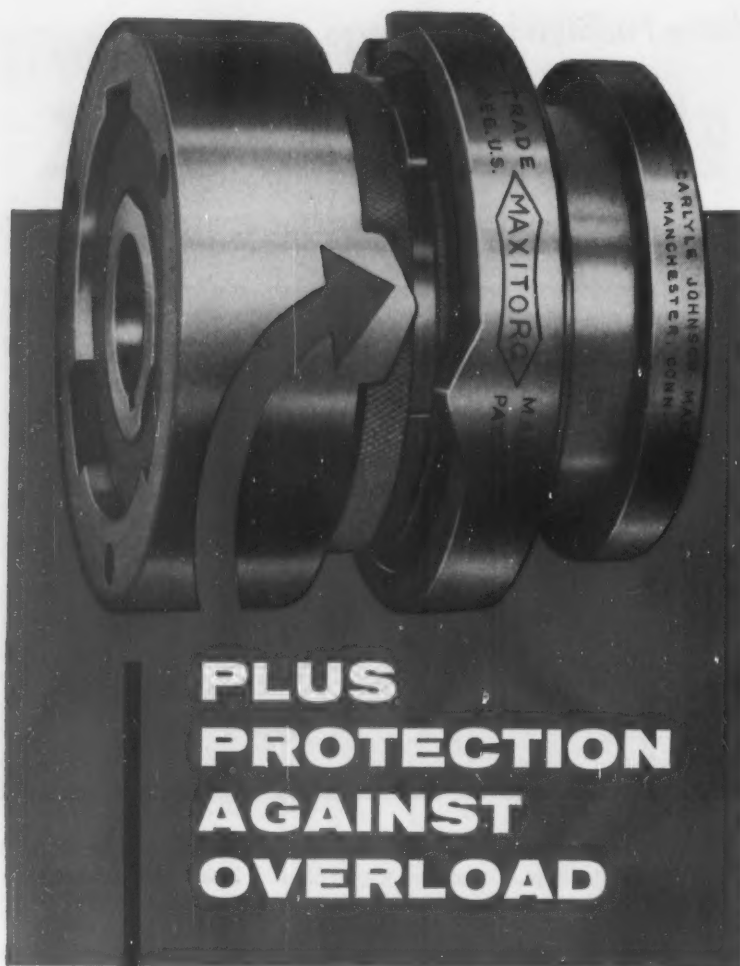
Where does the versatile Simmons LINK-LOCK belong in your design? For complete information and specifications, send for the Simmons Catalog today. Samples and engineering service available upon request.

**SIMMONS**  
**FASTENER CORPORATION**

1756 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • ROTO-LOCK  
LINK-LOCK • DUAL-LOCK

See our 8 page catalog in  
Sweet's Product Design File



**PLUS  
PROTECTION  
AGAINST  
OVERLOAD**

## **Maxitorq**

**overload release clutches**

Designers and builders have found MAXITORQ Overload Release Clutches the ideal way to provide dependable protection against overload conditions.

Unlike such devices as shear pins, the MAXITORQ Overload Release Clutch requires no disassembly or replacement after functioning. Once the cause of overload is removed or corrected, the machine may be re-started at once. Furthermore, MAXITORQ Overload Release Clutches may be adjusted for pre-determined overload protection.

In addition, users enjoy the proved advantages of the MAXITORQ Floating Disc Clutch... smooth, positive engagement and release... "floating" neutral with no drag or heating... easy manual adjustment.

We will be glad to give you the benefit of our long and successful experience in clutch and brake design; the overload release clutches are only one of many advanced MAXITORQ developments in both manual and electrically operated applications. Ask for literature, or outline your problem... write Dept. MD.



**THE CARLYLE JOHNSON MACHINE CO.**  
**MANCHESTER • CONNECTICUT**

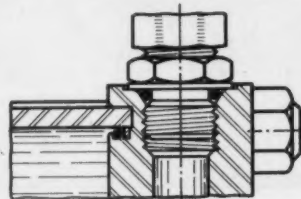
### NEW PARTS AND MATERIALS

phase ac output. Voltage amplitude and frequency vary in direct proportion to shaft speed. It is used for a reference generator to provide information on the rotational speed and angular position of a shaft, as in constant-velocity servo systems. It also can be used on systems for circular sweep generation on a CRT, utilizing the two-phase output phase relationship to position the beam on the scope face. Cedar Engineering, Div. of Control Data Corp., 5806 W. 36th St., Minneapolis 16, Minn. **H**

Circle 674 on Page 19

### Hydraulic Cylinders

have straight-thread ports



Series H hydraulic cylinders are now available with straight-thread ports as standard. Benefits include: 1. Low leakage. 2. No distortion due to wedging action of pipe-thread connection. 3. Elimination of pipe dope. 4. Exact positioning of the fitting without overtightening or back-off. Hannifin Co., Dept. 116, 501 South Wolf Rd., Des Plaines, Ill. **J**

Circle 675 on Page 19

### Short-Stroke Potentiometer

is linear-motion unit  
for 40 g vibration

Noise-free at 40 g vibration, Model 157 Align-O-Pot is a lightweight, short-stroke linear-motion potentiometer. Self-aligning shaft permits measurement of linear displacement even when perfect alignment with an actuating member is impossible or under high-vibration conditions; also, free lateral movement of an actuator is possible without side-load effect on the instrument. Specifications are: Standard travel ranges, 1/2, 1, and 1 3/8 in.; resistance, 1000 to 20,000 ohms; power rating, 1.5 w per in. at 40 C; operating temperature range, -65 to +374 F; weight,

*...unusual features solve your cylinder problems*

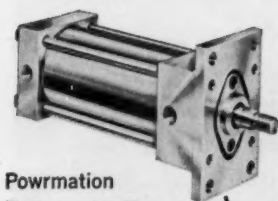
## **NEW HANNA** *Powrmation* SERIES 1000 **CYLINDERS**

### **Pressure Safe Tube Seals**

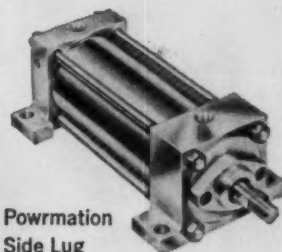
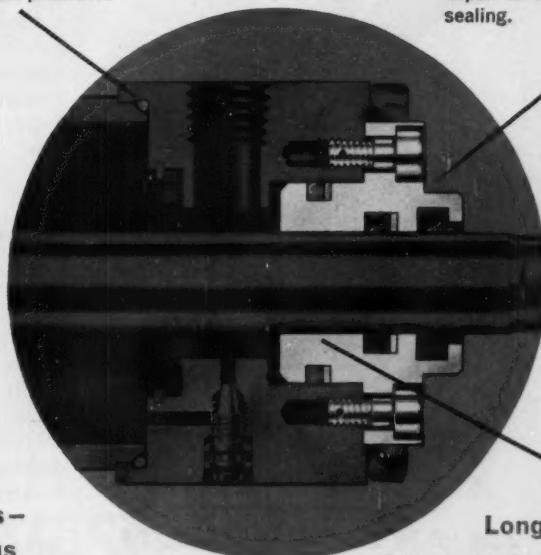
on the outside diameter of the tube create the most positive seal possible at all pressures from zero to maximum.

### **Fast Change Cartridge Gland**

has leak-proof, low-friction rod seal and a rod wiper to remove dirt and to provide extra sealing.



Powrmation  
Rectangular Flange  
Rod End



Powrmation  
Side Lug  
Mounting

### **One Piece Steel Heads— Welded Steel Mountings**

for maximum strength, perfect alignment... superior to bolted assembly. Mountings carry maximum cylinder load with ample safety margin.

### **Long Lubricated Bearing**

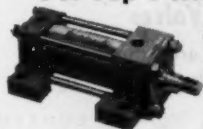
of close-grained nodular iron with high graphitic content... one of the finest bearing materials. Rod seal on external side of bearing provides automatic bearing lubrication by hydraulic fluid or airborne lubricant.

POWRMATION CYLINDERS FOR AIR TO 250 PSI • HYDRAULIC TO 1000 PSI • BORES: 1½" THROUGH 14"

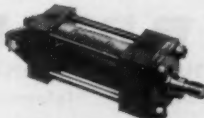
All good cylinders have "features" but few have a combination of really *Unusual* features that assure superior cylinder performance and dependability... New Hanna Powrmation Cylinders have. The features shown above and several others like: Unique, Check-Valve Cushions; Low Friction Nodular Iron Pistons; Posi-

tive Seal Block Vee Packings; Chrome Plated High Strength Steel Rod;—all these together with Hanna precision manufacturing and Hanna Field Engineering Service are the reasons why it will pay you to specify Powrmation Cylinders... they meet J.I.C. recommendations and have dimensional interchangeability.

### **For Top Performance in Hydraulic Pressures**



2000 PSI/3000 PSI Non Shock  
**HANNA POWRDRAINIC**  
Series 2000 CYLINDERS  
Bores 1½" thru 8"



### **Write for Catalog 1000**

or ask Your Hanna  
Representative—  
see the Yellow Pages  
or Sweet's Design  
Catalog for his name

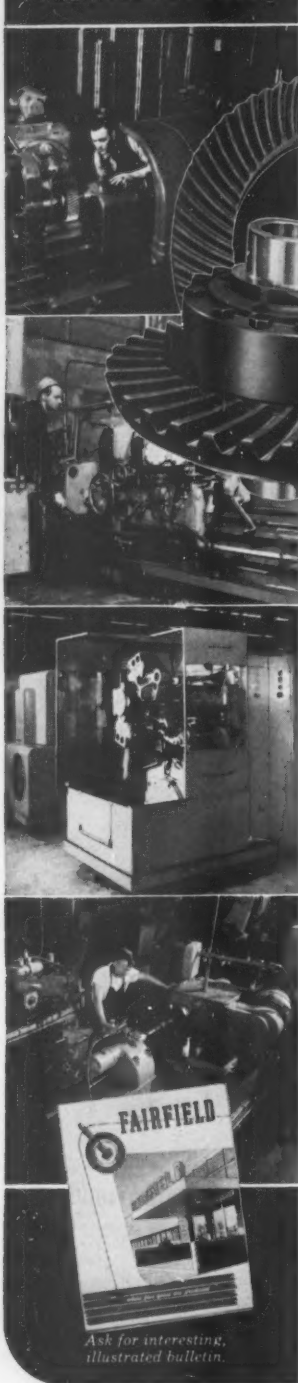


## **HANNA ENGINEERING WORKS**

HYDRAULIC AND PNEUMATIC EQUIPMENT... CYLINDERS... VALVES

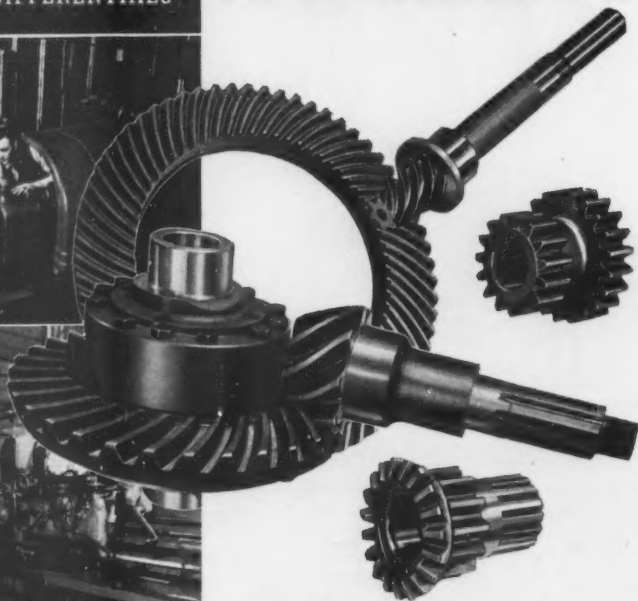
1751 Elston Avenue • Chicago 22, Illinois

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## NEW PARTS AND MATERIALS



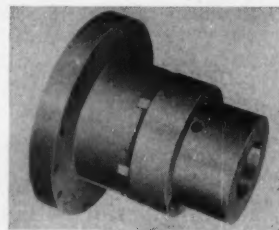
approximately 1.2 oz depending on travel. Unit will operate reliably at 40 g up to 2000 cps with error less than 1/2 per cent. Single or dual potentiometer outputs. Case is fitted with a flexible cable and a plug connector for easy installation, with optional cable lengths and connectors available, or wire leads. Bourns Inc., 6125 Magnolia Ave., Riverside, Calif. L

Circle 676 on Page 19

## Heavy-Duty Coupling

for shafts to 5 1/2 in. diam

Model GHF flange-type coupling is for heavy-duty use in sizes from 35 to 700 hp at 1800 rpm and for shafts up to 5 1/2 in. diam. Flange is for use on internal-combustion engines where coupling must be bolted directly to flywheel. Interlocking metal jaws of coupling are separated by nonmetallic load cushions. Removable individual inserts are held in place by a steel collar for easy inspection or replacement



without disturbing driving or driven units. Inserts are available to meet all operating conditions and government specifications. Gerbing Mfg. Corp., Elgin, Ill. J

Circle 677 on Page 19

## Plug-In Air Valves

all circuits are completed automatically on assembly

Pilot-operated, four-way control valves reduce maintenance time, since all power connections are made permanently in manifold or sub-base, and need not be disturbed for in-service maintenance. Electrical and pneumatic circuits to

NO "STICTION" \*  
Sensitive Response to any Pressure

## RIVETT SQUAREMASTER "100" CYLINDERS

Here's sure power for unfailing cylinder operation. SQUAREMASTER 100's are the world's finest constructed cylinders—perform with 100% efficiency! 200 P.S.I. air to 500 P.S.I. oil. Available in 7 mountings with standard dimensions, in 10 bore diameters, internal and external threading. Special models and cover combinations. Priced competitively; prompt delivery; meet all J.I.C. requirements.

**RIVETT, INCORPORATED**

Dept. MD-2, Brighton 35, Boston, Mass.

\*Initial High Coefficient of Static Friction

Send for  
catalog.  
Proof of  
SQUAREMASTER  
efficiency  
stated in these  
20 pages. Write today.



# RIVETT

## Unfailing POWER for MILLIONS of cycles!

### POWER-PACKED FEATURES PROTECTED BY POWER-GUARD CONSTRUCTION

1. Piston rod. Ground and polished alloy steel. Hard chrome-plated.
2. Piston rod bearing. Replaceable cartridge-type.
3. Piston packing adjusts automatically. V-block packing minimizes friction.
4. Correctly stressed tie rods.
5. Cushion bushings. Bronze, floating type.
6. Ports rotated to any 90° position.
7. Steel covers. Take minimum mounting space.

furnishes a complete power package

AIR AND HYDRAULIC — VALVES, CYLINDERS, POWER UNITS

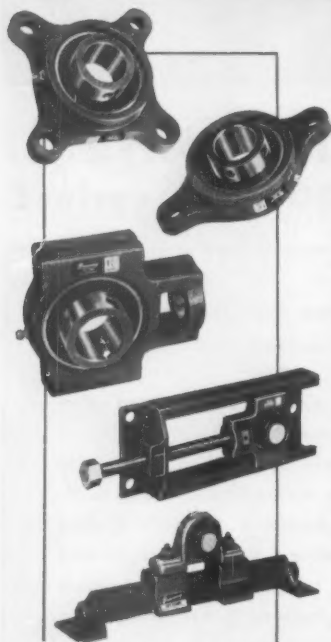
Member — National Fluid Power Association

# Browning

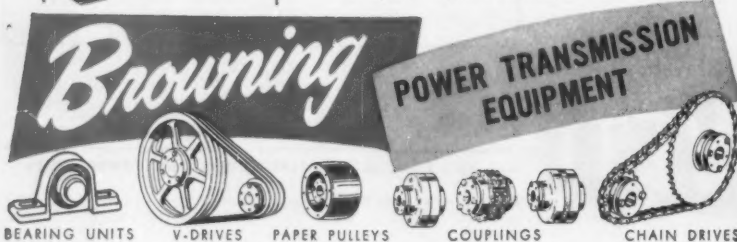


## BEARING UNITS

with Malleable Housings  
now available in **RELUBE TYPE**



When you need a relube type bearing unit, you can get more compact design and lighter weight by specifying Browning. Reason: these new pillow blocks, flange blocks and take-up units have housings of *unbreakable malleable*, which is stronger and virtually indestructible even under the most punishing loads. The new relube type units feature self-aligning ball bearings secured to the shaft by two set screws in the wide inner ring. All have elongated bolt slots for wide adjustment and maximum interchange. Available in 29 shaft sizes from  $\frac{1}{2}$  to  $2\frac{1}{16}$ ". New catalog BU-103 containing complete details is available on request from your Browning distributor. Or write to Browning Manufacturing Company Maysville, Kentucky.



BEARING UNITS

V-DRIVES

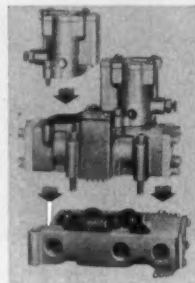
PAPER PULLEYS

COUPLINGS

CHAIN DRIVES

### NEW PARTS AND MATERIALS

valve and pilot are completed automatically as these units are plugged in and bolted down. Basic  $\frac{1}{2}$ -in. single or double-solenoid valves provide fast response with new short-stroke design. Separate, coded four-wire circuits on double-solenoid models meet JIC requirements. Design has only three moving parts. Valve bodies and sub-bases are heat-treated aluminum alloy, with stainless-steel end caps and hard-chrome-plated stainless-steel stems. Pilot coils, encased in molded epoxy resin, are guaranteed against coil burn-out for life. Designed for 35 to 200 psi air service, valves are available with solenoid coils for ac



or dc, any voltage or cycle. Integral junction box is standard. Options include manual over-ride and sub-base connected external pilot supply. Separate exhaust ports are tapped  $\frac{3}{4}$  in. NPT, with  $\frac{1}{2}$  or  $\frac{3}{4}$  in. NPT inlet and cylinder ports. Valvair Corp., 454 Morgan Ave., Akron, 11, Ohio.

F

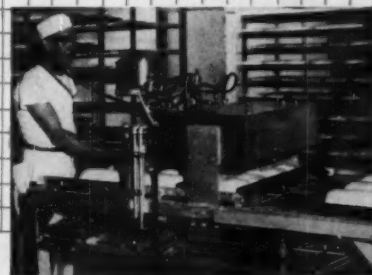
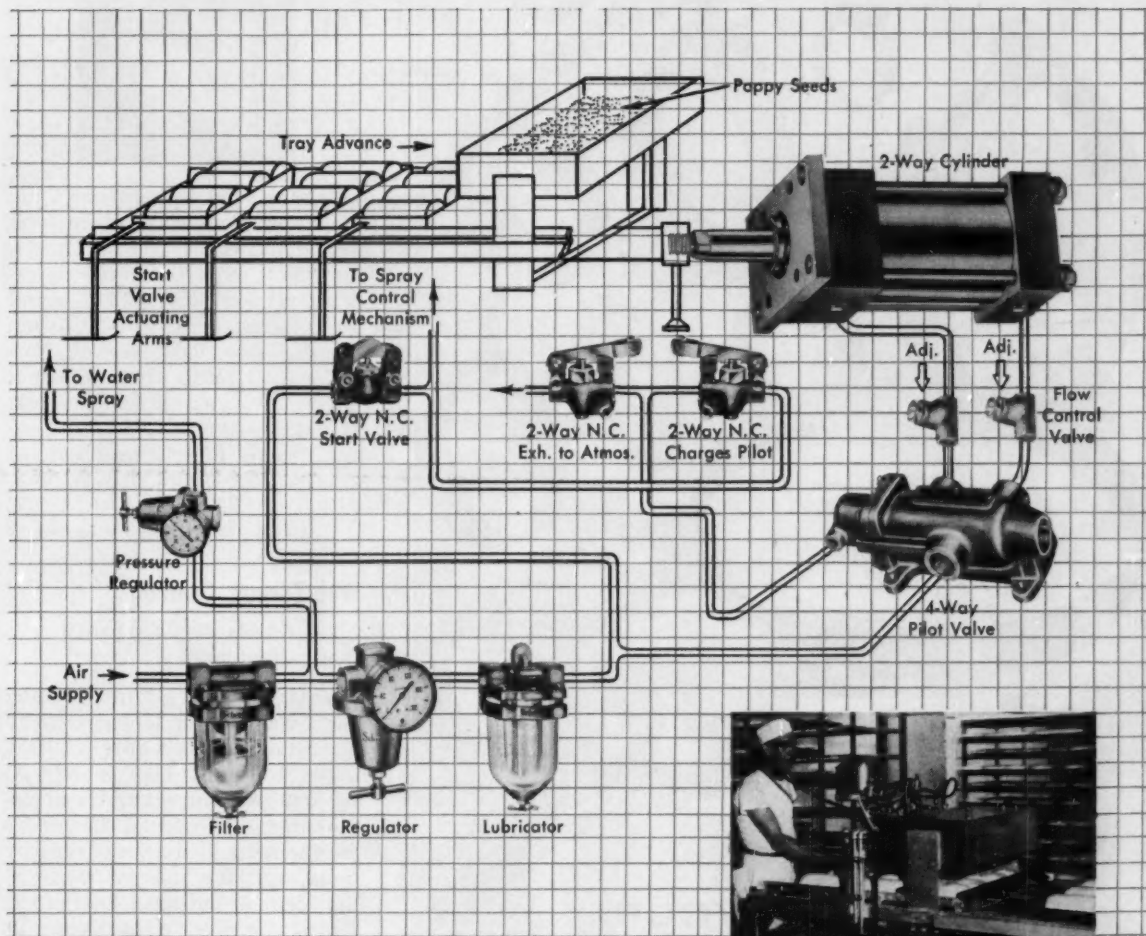
Circle 678 on Page 19

### Limit Switch

vane operates unit  
without actual contact

One-third smaller and with a wider vane opening than the previous model, new vane-operated switch can be front or top operated. Device is energized by the passage of a metal vane through a recessed slot. The vane disturbs a magnetic field balance which causes hermetically sealed contacts to operate. Magnetic dust and chips in the vane slot will not cause false operation. The new switch, designed for use in controlling machinery travel, will cost approximately one-third less than the previous model. Front or top operated models are available, with normally open or normally closed, single-pole contacts,

# PLANT MAKES STANDARD SCHRADER AIR PRODUCTS DO 65% OF THE WORK AUTOMATICALLY



Get full productive power from your manpower and machines, like this company. Simply take advantage of the air you already have! Hook up Schrader Air Products to fit your needs and get these benefits:

**AIR IS FAST AND ACCURATE:** time operations to fractions of seconds, produce at high speed. **AIR IS TIRELESS:** keeps going when fingers fail. **AIR IS ECONOMICAL:** saves you time, money and effort. **AIR IS SAFE:** reduces operator fatigue and machine-fear.

These are benefits every shop needs. Get them all when you automate with Schrader . . . the finest line of Air Cylinders, Valves and Accessories . . . and ideas for cutting your operating costs.

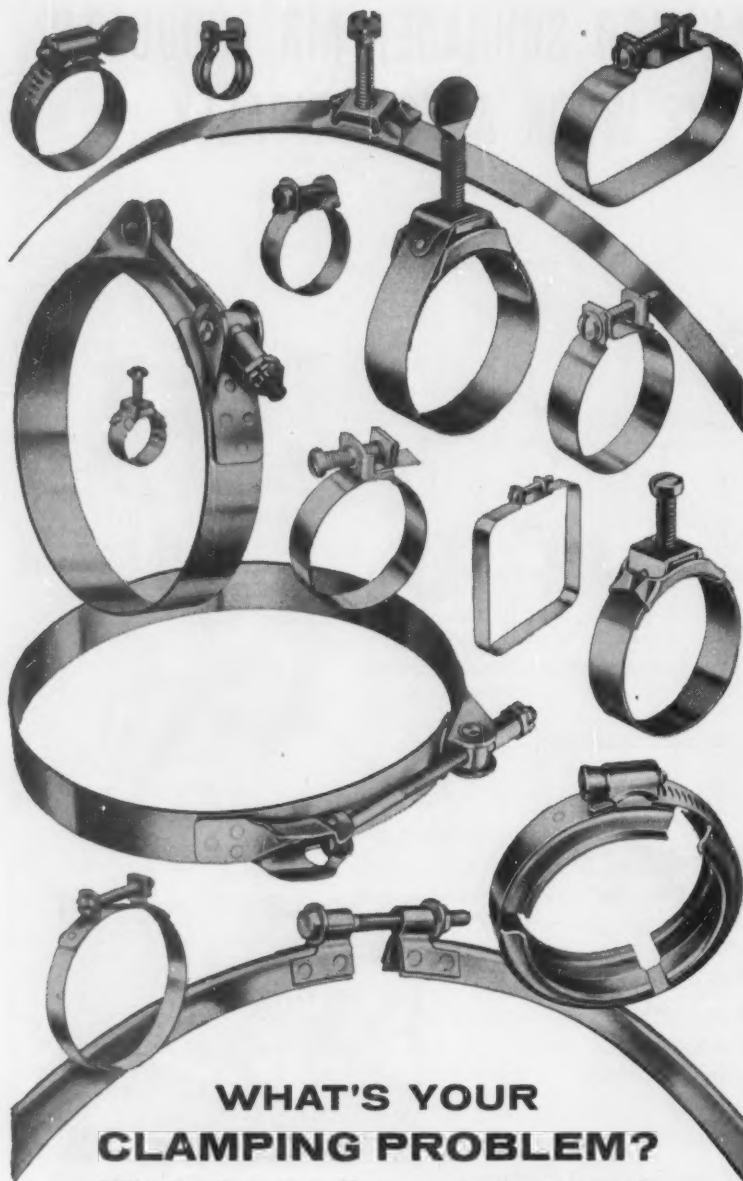
Here's a typical example of how companies can automate with air. The hookup of Schrader Air Products in the large picture was used to perform repetitive operations by General Baking Company, Detroit, Michigan. A tray of loaves moving on a belt trips a Schrader 2-way valve which actuates the water spray mechanism—and starts the 4-way valve-operated reciprocating system. The 4-way valve operates the cylinder which sifts poppy seeds onto each loaf in turn. This was formerly repetitive hand work. Schrader representatives helped plan this effective air system, as they have helped plan innumerable others.

Use the full Schrader line to do your air control selecting. Your Schrader distributor can help you pinpoint what you need. For more data write:

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QUALITY AIR CONTROL PRODUCTS



## WHAT'S YOUR CLAMPING PROBLEM?

**Wittek has the answer**—Here are a few from among the many different types and sizes of clamps designed and manufactured by WITTEK. Whatever the clamping problem on hose, plastic pipe, duct or other connections, it's a safe bet that WITTEK has the exact type and size clamp to do the job right! Let WITTEK help solve your clamping problems. Write today.

*Quality Clamps for Over a Quarter Century*

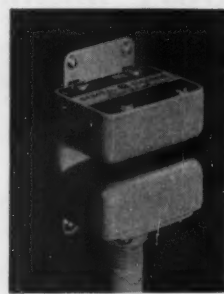
**WITTEK Manufacturing Co.**  
4340 West 24th Place, Chicago 23, Ill.



0011

Circle 504 on Page 19

## NEW PARTS AND MATERIALS



with or without an indicating light. Mounting plate with either form can be rotated 90 degrees. Operating life is long; the switch is capable of over 250 million operations. Repeatability is  $\pm 0.0025$  in.; response time, 0.001 second. Normal contact rating of the switch is 115 ac, 0.2 amp make or break; maximum rating is 0.75 amp. **General Electric Co.**, General Purpose Control Dept., Schenectady 5, N. Y.

C

Circle 679 on Page 19

## Web-Torque Control

has double torque capacity of present units

Internal bridging of two rotating parts doubles the torque capacity of existing CF400, CF511, FL1000, and 15LT units. Cost is only 50 per cent over the price of a single-capacity unit. External dimensions are the same as the single capacity units, and the internal construction permits the same low torque. Unit is applicable to torque or speed-controlled transmissions from fractional to 150 hp. Unit has a one-knob control box for clutch and brake, and uses oil shear for torque, for cooling through recirculation, and for lubrication. **Web Control Corp.**, Dept. AF, 318 Briarcliffe Rd., West Englewood, N. J.

D

Circle 680 on Page 19

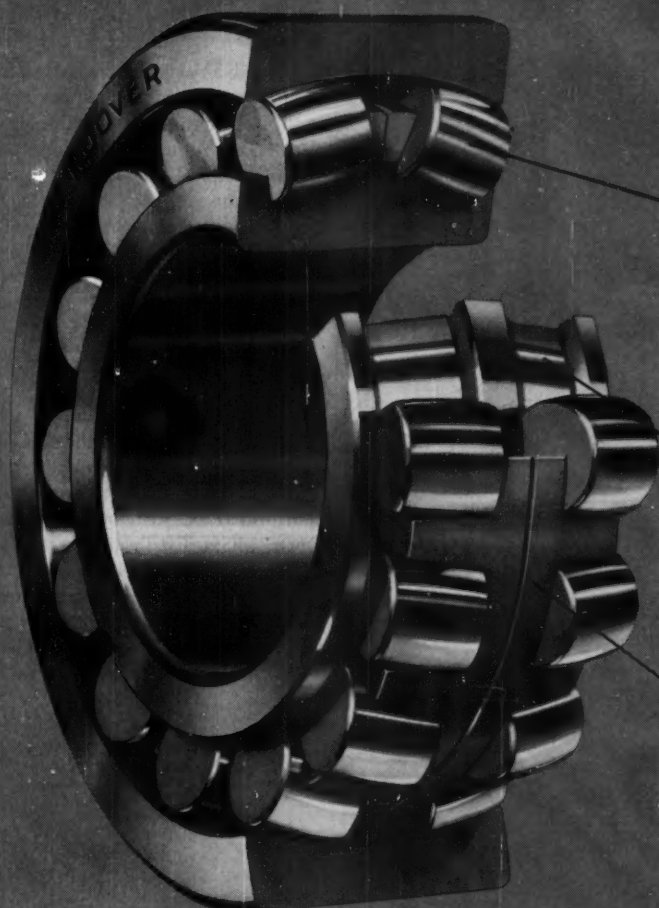
## Compact Pumps

are lightweight, compact, motor-mounted units

Compact, motor-mounted Viking 656 pumps are light in weight. Typical applications are for pressure lubrication, filtration, circulation, and transferring of liquids up to 750 SSU. Built with steel-fitted, bronze-fitted, or all-bronze construction, the new pumps include 2/3,

# hoover quality

...WHAT IT MEANS IN SPHERICAL ROLLER BEARINGS



**Super Finish  
ROLLERS**

**Super Finish  
RACEWAYS**

**MACHINED  
BRONZE  
RETAINERS**

In spherical roller bearings, *Hoover Quality* means extra smoothness, extra precision, extra bearing performance.

Large size rollers are *Super Finished* to a mirror-like smoothness to minimize friction.

Both inner and outer raceways are *Super Finished* to match the smoothness of the rollers. Precision matching of rollers and raceways assures

low operating temperatures and long life.

Land-riding retainers are accurately machined from solid bronze for proper roller guidance and uniform load distribution.

*Hoover Quality* spherical roller bearings are available in a complete range of sizes and series in cylindrical or tapered bore. Return the coupon below for complete information.

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**BALL AND BEARING COMPANY**

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Hoover Ball and Bearing Company  
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MD-2

- ☐ Please send Bulletin 113 which describes Spherical Roller Bearings.  
☐ Have your representative call.

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# Psychlo-switch\*

A multiple-strand precious metal brush fixed to a rotating arm . . .

engaging a flush printed circuit with nickel-rhodium plated conductors

. . . is a proven switching method.

Joined to the fast and durable Sigma Cyclonome® Stepping Motor . . .

results (obviously) in a fast and durable stepping switch, imaginatively entitled the Cyclo-switch. Since the principal component is the Cyclonome motor, all its characteristics apply to the Cyclo-switch: operation on magnetic reversals (no reciprocating parts), with each reversal producing exactly 18° of shaft rotation. The Cycloswitch will seek out and stop at any one of its 10 and/or 20 positions on command. It will run at either constant or random rates, up to 240 steps/sec. Power required varies from 1 to 10 watts, depending on speed and the number of brushes.

Brushes and switch segments will carry 1.5 amps in 250 VDC circuits; applications controlling Sigma relays with 20-40 ma from 120 VDC, with proper arc suppression, have given long, trouble-free service. Life up to 75,000,000 revolutions with light loads is possible.

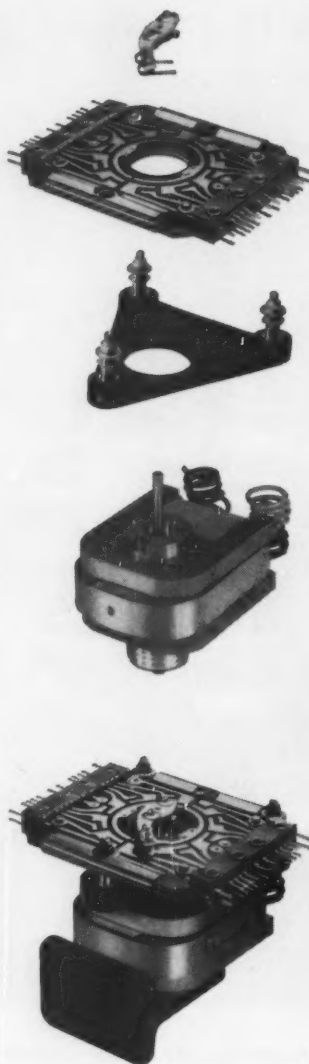
All sorts of combinations of decks, arms, wipers, brushes and delivery schedules are possible. The simple one-deck two-brush model shown lists for \$95; in production quantities the price drops down to about \$50. By now we hope you're interested in inquiring further about the Sigma Series 9C "Cycloswitch."

\*for psyncopated switching

## SIGMA

SIGMA INSTRUMENTS, INC.  
89 Pearl St., So. Braintree 85, Mass.

AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1939)



## NEW PARTS AND MATERIALS



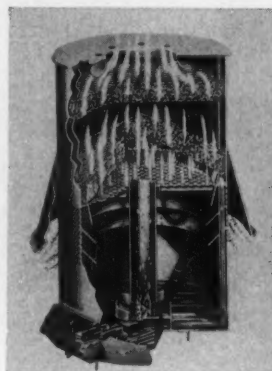
1½, and 3½ gpm sizes. Mechanical seals or conventional packing are optional. Units are available with ¼, ⅓, or ½-hp, single-phase, 1750-rpm motors—open or explosion-proof type. All sizes use the same mounting-flange bracket. Viking Pump Co., Cedar Falls, Iowa. I

Circle 681 on Page 19

## Air Cleaner

self-cleaning unit  
has no moving parts

Oil-bath air filter, model C P01 Cycoil, has a pneumatic lift which lifts oil from the reservoir to the perforated oil distribution plate. In turn, oil is distributed to the pads. Electric-motor-driven oil circulator is eliminated. Unit has cleanout



door for easy maintenance, and "bullseye" gage to observe oil level. American Air Filter Co., Dept. PD, 215 Central Ave., Louisville 8, Ky. G

Circle 682 on Page 19

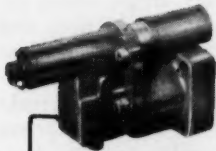
## Rotary Switch

for control of  
automatic-cycling equipment

Switch shuts off the power at the end of each rotational cycle, and automatically starts the cycle unless interrupted. The switch is connected to an external solenoid (not supplied) which actuates the cycle.

# RACINE-SECO®

Variable Volume Vane Type **PUMP CONTROLS ...**



#### MOTORIZED CONTROL

Electric motor with reduction gear or screw shaft provides accurate and prompt adjustment of pressure or delivery through push-button stations or limit switches.



#### TWO-PRESSURE CONTROL

Remote or direct hydraulic pilot operation allows automatic selection of two independently adjustable direct pressures.



Special governing springs, having a heavier spring rate, allow pressure ring to move to neutral position at a lower value of pressure, thereby reducing required peak horsepower.

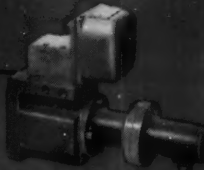


#### CYLINDER CONTROL

Remote hydraulic pressure selects two preset deliveries. Allows rapid travel and reduced speed resulting in conservation of input power.

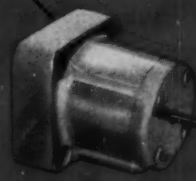
#### ELECTRO-HYDRAULIC CONTROL

Electronic precision control of delivery or pressure for multiple pre-selected pump displacement, multiple pressure functions, accurate feedback control of output speed, torque, position or power.



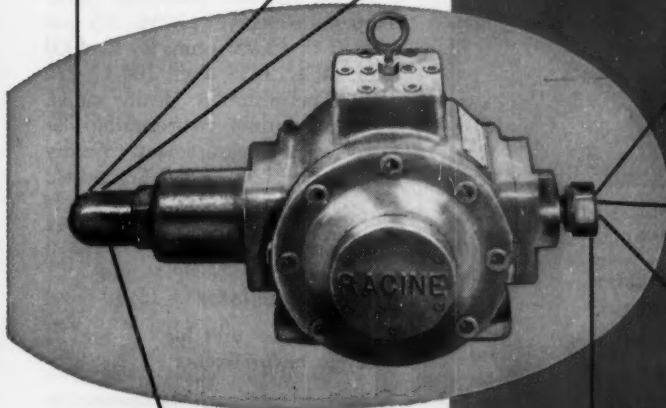
#### SERVO FORCE AMPLIFIER

Steady control provides rapid acceleration, controlled follow-up, or pressure control. Extremely low forces are multiplied to control pump delivery or pressure accurately.



#### LEVER VOLUME CONTROL

Positive control of pump output, from zero to full volume, can be obtained when it is desirable to impart variable speeds to a cylinder or other driven member during the operating cycle.



#### FLOW FEED-BACK CONTROL

Remote hydraulic automatic positioning to hold constant flow rate regardless of system pressure or pump drive speed. Operates only at pressure to do the work.



Write for Catalog No. 59-A describing RACINE-SECO complete line of Hydraulic Equipment.



**RACINE HYDRAULICS & MACHINERY, INC.**  
RACINE, WISCONSIN

One Source — One Responsibility for all your hydraulic needs

# SOLVE DESIGN and MAINTENANCE PROBLEMS



SPECIFY

## STRATOFLEX

HOSE AND FITTINGS

Stratoflex was specified for the precision hydraulic tracing control kit on this tool room milling machine.

When you design with Stratoflex you get more than the vibration and stress resistance inherent in flexible hose. You get hose fittings designed to meet your specific requirements. And with Stratoflex leak-proof reusable fittings you simplify maintenance by making possible quick, easy replacement or modification. You solve both design and maintenance problems when you specify Stratoflex.

Write for  
Bulletin  
S-2 today

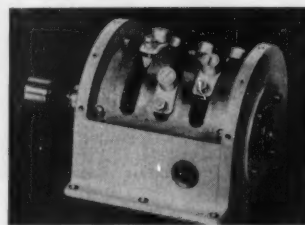
SF10-9

## STRATOFLEX

P.O. Box 10398 Fort Worth, Texas  
Branch Plants: Hawthorne, Cal., Fort Wayne, Toronto  
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Milwaukee, New York  
Philadelphia, Pittsburgh  
San Francisco, Seattle  
Toronto, Tulsa

### NEW PARTS AND MATERIALS



Cycling time can be adjusted within limits. Basic switch shown is adaptable to any design where cycling is required. Brush, ring, and insulation materials are selected to withstand arcing caused by induction of the circuit. Switch breaks 3 amp at 115 ac. **Superior Carbon Products Inc.**, 9115 George Ave., Cleveland 5, Ohio. F

Circle 683 on Page 19

### Disc Thermistor

stock unit matches curve  
within  $\pm 5$  per cent

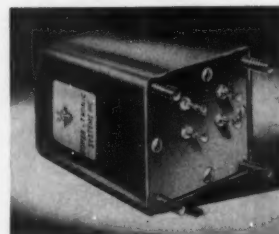
Previously made only to order, Veco 34D4 disc thermistor is now available from stock. Resistance matches following nominal resistance versus temperature curve within  $\pm 5$  per cent: 0 C, 13,096 ohm; 25 C, 4000 ohm; 50 C, 1438 ohm; 100 C, 270 ohm. Thermistor is ideally suited for temperature compensation or temperature measurement. **Victory Engineering Corp.**, 536 Springfield Rd., Union, N. J. D

Circle 684 on Page 19

### Voltage Regulator

is miniature unit for  
severe environments

Transistorized regulator operates in ambient temperature of  $-55$  to  $+125$  C and meets MIL-E-5272. Available output voltages are between 35 and 150 dc at load currents up to 500 ma. Regulation is 0.1 per cent for input variations of  $\pm 20$  per cent and load variations from zero to full load. Models with

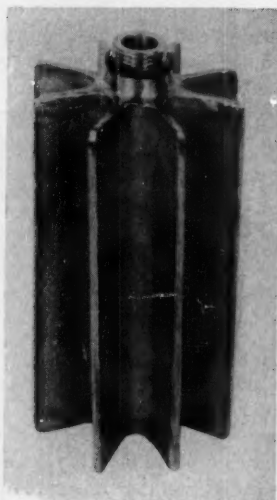


0.05 per cent regulation are also available. The unit measures  $2\frac{1}{2}$  x  $2\frac{1}{2}$  x  $2\frac{3}{4}$  in. and weighs 15 oz. Power-tronic Systems Inc., 10 Pine Court, New Rochelle, N. Y. D

Circle 685 on Page 19

### Stainless-Steel Filter

has high flow and large cake capacity



High flow, large cake capacity, and small size are features of Star S-78 porous stainless-steel filter element. Contained in a 4 in. diam housing, the filter is available in lengths from 6 to 18 in. with filtration ratings down to 2 microns. Operating pressures range from full vacuum to 125 psig, and operating temperatures up to 300 F. Very large surface area per unit volume permits high flow rates and low pressure drops. Both filter and housing are stainless steel. Housing has quick-opening construction. Designed to prevent contaminant from going downstream of the filter, the housing and element are removed downward when the filter is cleaned; this keeps the slurry within the lower portion of the housing. Micro Metallic Div. of Pall Corp., 30 Sea Cliff Ave., Glen Cove, N. Y. D

Circle 686 on Page 19

### Hour Meter

records running time of ac-operated machines

Accumulated time of operation up to 10,000 hr is registered. A con-



## Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive

and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66av.

# DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS

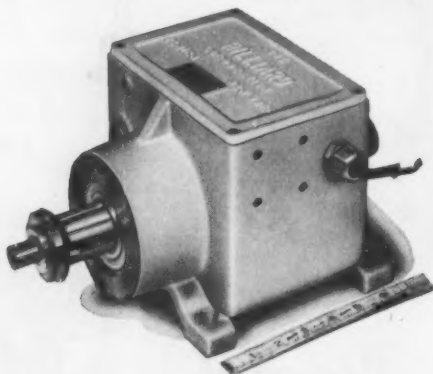
Ratchet • Screw  
Hydraulic • Worm Gear



COFFING HOISTS

Ratchet Lever • Air  
Hand Chain • Electric

# HILLIARD'S *New* "I.D.U."



**A complete, packaged unit that gives you precise control of intermittent motion from a constant rotary power source!**

## Built-in features:

- Contains all the parts in one package.
- Can be installed as easily as a motor and needs only electrical connection.
- Self-lubricating for long life of 40,000,000 or more cycles.
- Operating speed from 40 to 400 R.P.M.
- Torque capacity 36 ft. lbs.
- No cumulative error in cycling.
- Instant engagement.
- Mount with direct coupling connection or use with belt, chain or gear drive.

**Can be installed on existing equipment, designed into new machinery and re-used after production line changes.**

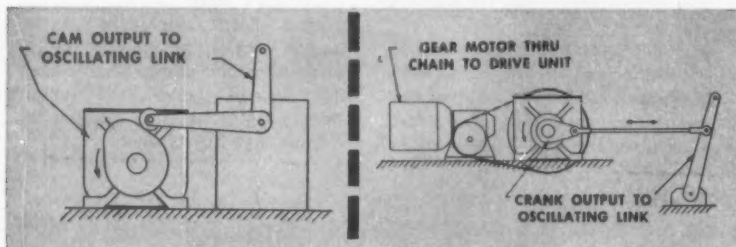
A single package unit that gives you precise control of intermittent motions . . . oscillate or repeat . . . clip and bend . . . shear or slash . . . raise or lower . . . index and position . . . from a constantly rotating source of power.

HILLIARD "I.D.U." eliminates the need of buying separate parts and assembling a "custom" machine with assorted mechanisms to control it.

"I.D.U." features highly flexible control—manual, mechanical or electrical—permitting "demand" type operations in fixed or variable cycles. A protected drive, totally enclosed in an oil bath housing, it is ideal for dusty, "steamed" or "washdown" conditions.

Write on your letterhead stating your intermittent motion problems and we will provide complete information.

## Typical intermittent controls by "I.D.U."



**Basic Unit Price \$289.00**

Optional accessories extra

**The HILLIARD Corporation**

103 W. FOURTH ST. ELMIRA, NEW YORK

IN CANADA: UPTON-BRADEN-JAMES LTD.

## NEW PARTS AND MATERIALS



tinuous record of the running time for any equipment operating on alternating current can be maintained. Housed in a rugged, compact metal case, the instrument has easy-to-read, large figures. Engler Instrument Co., Jersey City, N. J.

Circle 687 on Page 19

## Skin-Tight Tubing

shrinks tightly over rods, tubes, or shapes

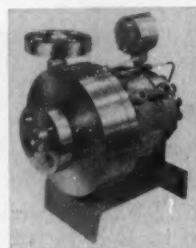
Vinyl tubing contracts at temperatures over 275 F to form skin-tight electrical insulating "armor" for symmetrical rods, tubes, or contoured shapes. Tubing is now available in 25 standard sizes to cover objects 5/64 to 5 in. ScotchTite Heat Reactive Tubing shrinks up to 30 per cent in diameter, 15 per cent in length, in 4 to 8 minutes at 300 F. Abrasion and chemical-resistant, the tubing is UL-recognized as electrical insulating material. Minnesota Mining and Manufacturing Co., Dept. E9-480, 900 Bush Ave., St. Paul 6, Minn. H

Circle 688 on Page 19

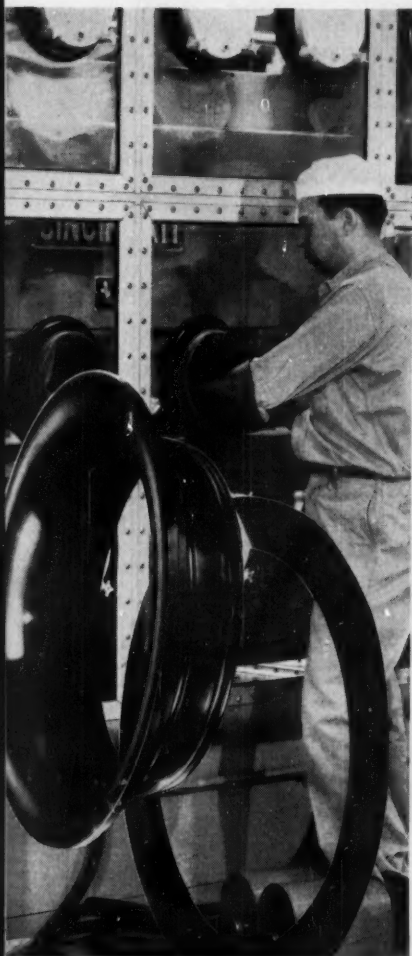
## Canned Pumps

for high-pressure service

Sealless, leakproof canned pumps for high-pressure service include models for open-flow capacities to 350 gpm, heads to 250 ft, and temperature to 1000 F. Standard units handle line pressures of 600, 900, 1500, 2000, and 2500 psi, with spe-



*Product-Design*  
**BRIEFS**  
*from Durez*



ARGONNE NATIONAL LABORATORY

**PHENOLIC PORTHOLES?  
WHAT NEXT!**

Atomic engineers have found a good way to seal those big gloves that handle plutonium and its deadly cousins in inert-atmosphere chambers.

The port you see here does this critical job well. It is compression molded of a Durez medium-impact phenolic. It doesn't leak. It also resists shock, corrosion and heat. Its smooth surface won't snag the rubber glove. And it is economical: metal inserts can be molded right in. Except for polishing off flash, it's all finished when it comes off the press.

Have you looked into atom-age phenolics lately? They're better, more versatile than ever. To see what they can do for you, check the coupon for our Bulletin D400. It lists properties, uses, advantages of many interesting Durez compounds.



**PUT THE BRAKES ON HEAT**

No, this isn't a magic powder you sprinkle on a product to make it resist heat. It is a material—Durez phenolic resin—that's used in scores of products as a *bonding agent* to impart controlled degrees of heat resistance.

Brake linings are just one example. Some others: electronic resistor coatings, shell molds and cores for foundry use and automotive generator brushes.

For heat resistance at low cost, you just can't beat phenolic resin. If you have such an application, write us the details and we'll gladly try to help you as we have helped many others.

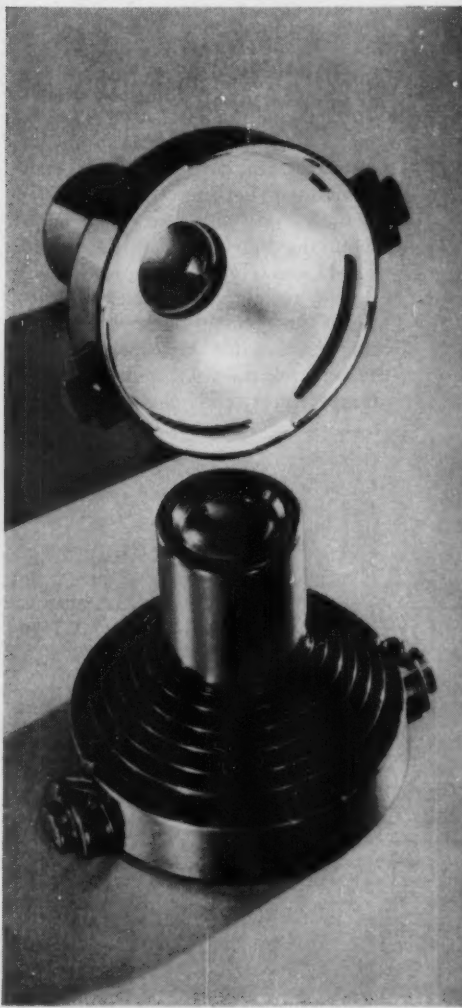
**BRIGHT IDEA:  
PLASTIC-METAL MIRROR**

Metallized phenolic saves a costly production step in this housing for a microscope lamp.

In place of a custom-made reflector, the molded phenolic housing has an aluminum mirror deposited right on it by vacuum metallizing.

The Durez compound chosen for this part has the right surface for metallizing, and incorporates high impact strength, low thermal conductivity.

You'll find many helpful ideas like this in *Durez Plastics News*, special bulletin mailed periodically to thousands of product-design men. A check mark on the coupon will bring *News* to you faithfully.



For more information on Durez materials mentioned above, check here:

☐ Phenolic molding compounds—descriptive Bulletin D400 ☐ Phenolic resins—illustrated bulletin describing uses ☐ *Durez Plastics News*—mailed periodically  
Clip and mail to us with your name, title, company address. (When requesting samples, please use business letterhead.)

**DUREZ PLASTICS DIVISION**

502 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKEER CHEMICAL CORPORATION



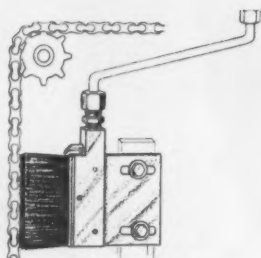
cials for 5000 psi. Since pump and motor are one unit, there are no seals or stuffing boxes; leakage is completely eliminated. Pumps are hydrostatically tested at  $1\frac{1}{2}$  times rated pressure. Pumps may be either bolt and gasket construction, or seal-welded. Leakproof vane pumps for gases at high static pressures also available. **Chemumpump Div., Fostoria Corp.**, P. O. Box 35-26, Huntingdon Valley, Pa. E

Circle 689 on Page 19

### Brush Oiler

for vertical chains

Vertical-chain oiling system consists of a brush applicator, an oil dispenser, and copper tubing. Brush is mounted horizontally on an aluminum body attached to a steel mounting bracket. Brush sizes are  $\frac{5}{8}$ , 1, and  $1\frac{1}{2}$ -in. diam, and  $\frac{3}{8}$  x  $2\frac{1}{4}$ -in. rectangular. Horsehair bristle is for general-purpose applications; nylon for high-speed operations; and stainless steel for high temperatures and chain cleaning.



System can be operated with either manually or automatically controlled oil dispensers. Shutting off the oil supply on the central oiler immediately stops drop feeding of the valves. Extra-fine metering valves to feed at an extremely slow rate are optional. **Oil-Rite Corp.**, 2376 Waldo Blvd., Manitowoc, Wis. J

Circle 690 on Page 19

### Flame-Retardant Laminate

is paper-base material  
with good mechanical properties

Fireban X laminated plastic complies with Underwriters Laboratories tentative requirements for flame retardance. Essentially a Grade X laminate with a special phenolic

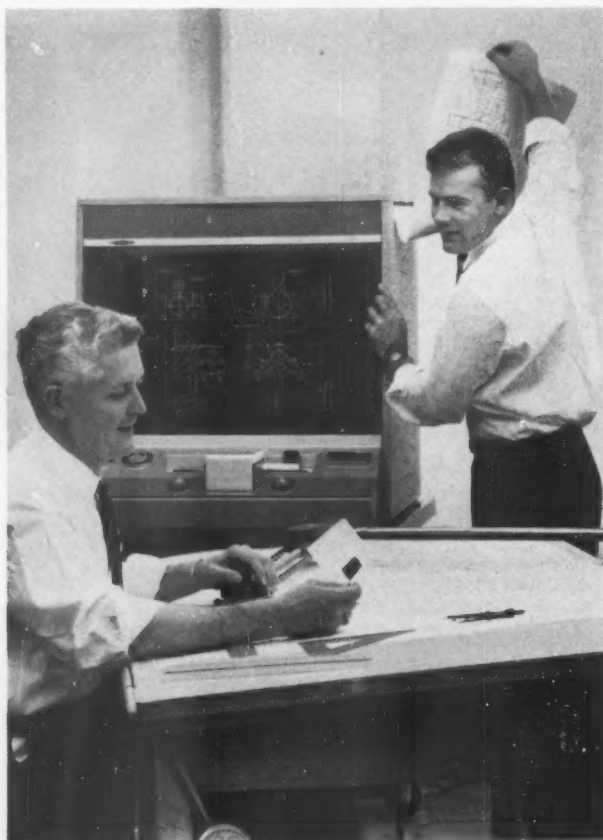
resin, it provides an extra measure of fire safety on applications where high tensile and flexural strengths are required. It also has good impact strength and dielectric strength. Available in sheets approximately 49 x 49 in.,  $\frac{1}{32}$  to 1 in. thick. Minimum properties in  $\frac{1}{8}$ -in. thickness are: Flexural strength, flatwise and lengthwise, 25,000 psi; tensile strength, lengthwise, 20,000 psi; max operating temperature, continuous, 225-250 F; dielectric strength, parallel to laminations, step by step, 25 kv. **Taylor Fibre Co.**, Norristown, Pa. E

Circle 691 on Page 19

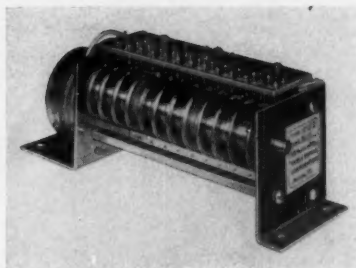
### Program Timer

contains 12 independent  
SPDT load switches

HYS Repeat Cycle Timer measures only  $2\frac{1}{4}$  x  $2\frac{1}{4}$  x 7 in. but contains 12 SPDT independently adjustable and removable load switches. Motor operates on 115-v, 60-cycle power. Time cycle is 90 seconds. Originally built for ground-support equipment, the timer will withstand vibration of 0.060 in. double-amplitude dis-



now...  
**3M makes  
microfilm  
so easy  
to use**



placement from 5 to 55 cps and shock of 30 g for 11 milliseconds. Extra-large cams (1 1/8 in. OD) allow time settings with an inaccuracy of 1 per cent or less. Eagle Signal Co., Moline, Ill. I

Circle 692 on Page 19

### EP Lubricant

moly disulfide dispersion  
for high wear resistance

Molybdenum - disulfide lubricant, Molykote M-55-Plus, is for extreme-pressure applications. It outperforms M-55 dispersion, its predecessor, by 116 per cent in welding-load tests and 71 per cent in wear-resistance tests. Suitable for slow-moving parts under heavy loads,

and for surfaces which would be reactive with additives, M-55-Plus is also recommended for wear-reduction applications in sleeve bearings and instrument gears, even though lightly loaded. A colloidal dispersion of submicron particles in mineral oil, it can be used in mist lubricators. MoS<sub>2</sub> particles show no tendency to settle out after extended periods. Physical specifications are: Viscosity, 530 SUS at 100 F and 57 SUS at 210 F; flash point and fire point, 340 F and 390 F, respectively; Shell four-ball welding load, 520 kg; mean Hertz load, 72; service temperature range, 0 to 250 F. Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn. B

Circle 693 on Page 19

### Power Switch

mercury contactor  
handles 20 amp

Power contactor, called Mega-Switch, is rated to 20 amp. Hermetically sealed contactor is for relays, flashers, machines, and installations where repeated contact is required. Contacts are between tung-

### NEW PARTS AND MATERIALS

sten and mercury, hermetically sealed in gas to prevent oxidation of points. Operates with low voltage on primary side. Available in a complete range of voltages. Explosionproof; dustproof. Switch can also be used under a voltage-control relay where a reduction in voltage would be dangerous, or as an overload voltage-control relay to pro-



tect expensive equipment from unusually high voltage surges. Energy Controls Inc., 15 South First St., Geneva, Ill. I

Circle 694 on Page 19

### Regulators and Control Valves

have sliding-gate seats  
for low flow requirements

Low flow sliding-gate seats on 1/4 through 3-in. size regulators and gate valves provide capacity to suit individual requirements. Example:

■ Each month more and more companies are turning to microfilm for engineering drawing reference systems. The reasons are many—but, most important is that 3M's new THERMO-FAX "Filmac 200" Reader-Printer makes microfilm so practical—so easy to use. ■ The "Filmac 200" Reader-Printer combines the advantages of a reader and a printer in a single low-cost unit. You can refer to the enlarged drawing clearly projected on the big screen, and make a work-size print in seconds. You can take more than a look—you can take a copy. You make copies of what you need when you need them. So low in cost, it puts microfilm in reach of even the smallest engineering firm or department. ■ If you are now using microfilm you will find the "Filmac 200" Reader-Printer will fit into your present reproduction system perfectly. Engineers save valuable time—in seconds your reproduction department can make enlarged prints for them—or they can even make their own. If you are considering microfilm, investigate the "Filmac 200" Reader-Printer first. Its low initial cost and low operating cost—plus its fast and simple operation—make the microfilm reference system practical and so easy to use.

Call your local dealer or mail the coupon now for complete information.



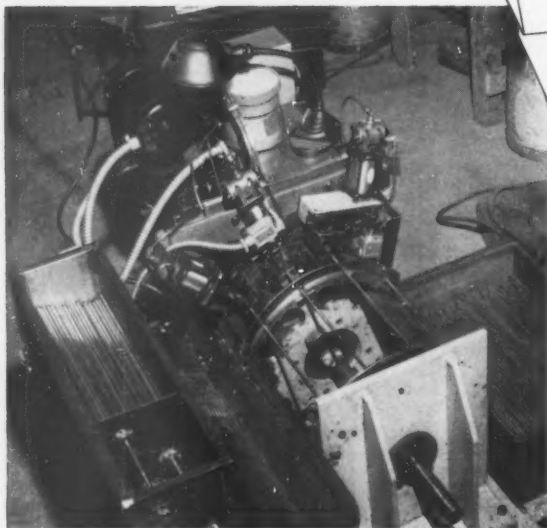
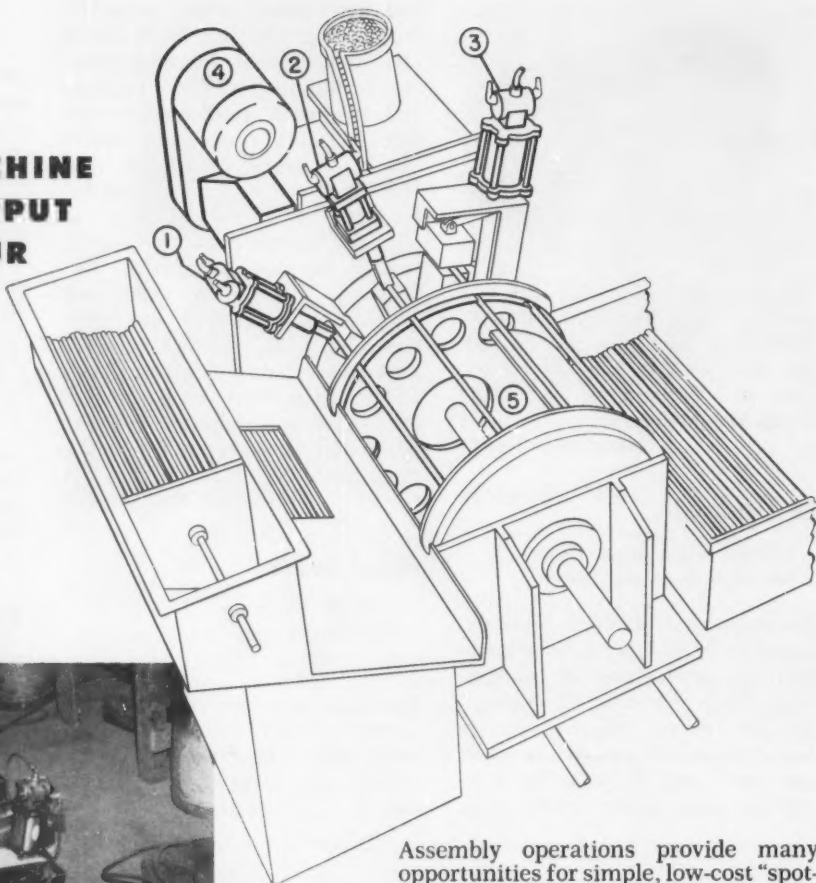
**MINNESOTA  
MINING AND  
MANUFACTURING COMPANY**  
... WHERE RESEARCH IS THE KEY TO TOMORROW

THE TERM "THERMO-FAX" IS A REGISTERED  
TRADEMARK OF 3M COMPANY

Minnesota Mining and Manufacturing Company  
Dept. FBO-240, St. Paul 6, Minnesota  
Please send me complete facts on the new THERMO-FAX "Filmac 200"  
Reader-Printer.

Name \_\_\_\_\_  
Title \_\_\_\_\_  
Company \_\_\_\_\_  
Address \_\_\_\_\_  
City \_\_\_\_\_ Zone \_\_\_\_\_ State \_\_\_\_\_

**THIS  
SHOP-BUILT MACHINE  
INCREASED OUTPUT  
PER MAN-HOUR  
500%**



Incorporating five Bellows Air Motors (#1, #2, #3, plus two others, horizontally-mounted, not visible) and a Bellows Drill Unit (#4), all electrically interlocked with the vertically-mounted Bellows Rotary Table (#5) which feeds the workpieces through the various operations, this machine counterbores one end of a .300" brass tube, inserts a small plastic seal, curls the end of the tube to retain the seal and delivers the completed antenna sub-assembly into a hopper ready for plating.

Assembly operations provide many opportunities for simple, low-cost "spot-automation" with Bellows "Controlled-Air-Power" Devices. Costs go down immediately as these versatile work units boost the productivity of each worker.

A case in point is this machine, built entirely around Bellows "Controlled-Air-Power" Devices, which performs an assembly sequence in the manufacture of automobile antennas. Designed by the Plant Superintendent working with a Bellows Field Engineer, the unit requires only one operator (who merely loads and unloads hoppers), yet produces the same number of pieces as five assemblers working manually.

This machine is typical of the ways that cost-conscious men are using Bellows "Controlled-Air-Power" Devices — either singly or in combinations — to perform a virtually-unlimited range of operations. It's almost a certainty that Bellows units can help you meet — or exceed — cost reduction goals in *your* plant, too.



**THIS SPOT-A-MATION IDEA FILE IS YOURS ON REQUEST**

Contains installation data, wiring diagrams and equipment lists for numerous Bellows "Controlled-Air-Power" applications, enabling you to automate existing machines or build your own low-cost special-purpose equipment. Write for yours today. Address Dept. MD 260, The Bellows Co., Akron 9, Ohio.

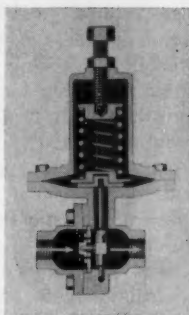
640-C

**The Bellows Co.**

DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION (IBEC)

**AKRON 9, OHIO**

OTHER INDUSTRIAL DIVISIONS OF IBEC: Sinclair-Collins Valve Co., Valvair, Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio



1 1/4-in. body size can have capacities of 1 1/4, 1, 3/4, 1/2, 3/8, or 1/4 in. Low-flow seats are used where initial requirements are for a low flow but later needs are for high flows, where strength of full line-size valves is needed but low flow is required, and to replace seats in an oversized valve body. Seats are stainless steel with industrial hard chrome finish. They are self-lapping and self-cleaning. OPW-Jordan Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 695 on Page 19

### Pressure-Sensitive Films

are available in new types

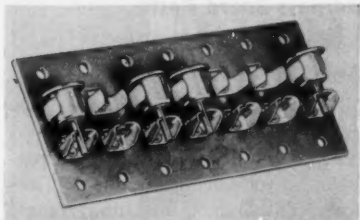
New line of Dri-Mark films, pressure-sensitive applied signs, includes: Dri-Mark vinyl; Mirro-Cal, a chrome-bright mirrorized film; clear Mylar; Mirro-Cal VML, a mirrorized vinyl Mylar laminate; and outdoor paper. Films are protected by a tough, durable clear top coat. Meyercord Co., 5323 W. Lake St., Chicago 44, Ill. I

Circle 696 on Page 19

### Mounting Clips

for "top-hat" diodes or rectifiers

Spring-tempered beryllium-copper mounting clips provide simple component installation and replacement of "top-hat" diodes or rectifiers,



February 4, 1960



The simplicity of the RBC PITCHLIGN design tends to underemphasize the functional principles engineered into each RBC PITCHLIGN Roller Bearing such as

- Even load distribution
- Absolute roller alignment
- Complete shoulder control of cage
- Minimum cage effort produces maximum roller effect
- Ample storage space for lubricant

Uniform load distribution can only be achieved with perfect roller control.

Perfect roller control in the RBC PITCHLIGN is achieved with a series of precisely engineered functional parts.

Under unbalanced loads or shaft misalignment the rollers try to skew away from the load—in turn—this results in an effort to skew the cage.

In the RBC PITCHLIGN roller bearing, perfect control is maintained on the rollers by accurately spacing and forming each window of the cage. Contact is made on the rollers' pitch circle for maximum control. In addition, the cage is controlled by the ground shoulders of the outer race, assuring that all of the rollers are properly positioned all of the time.

#### ROLLER

SAE 52100 through hardened steel. Precision-ground and lapped. Ends relieved to prevent concentrated end loading.

#### CAGE

Tubular steel for maximum strength. Windows have parallel sides to align rollers at their pitch circle. Broad flange-riding rims.

#### RACE

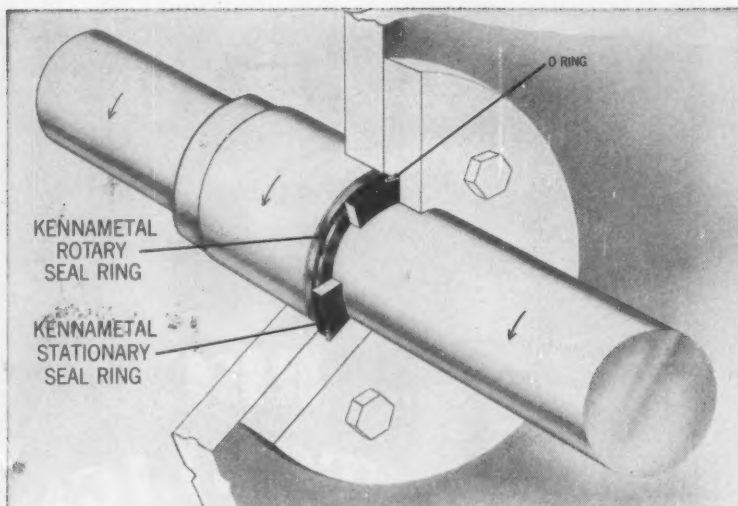
Martempered SAE 52100 steel. Channel shaped to give 360° support to the cage and axially locate the rollers. Sufficient sections for maximum structural strength without unnecessary space and weight.

Let RBC Engineers help you remove the friction from your design problems ... Insist on the best—The Pioneering PITCHLIGN.

ROLLER BEARING COMPANY OF AMERICA  
Sullivan Way, West Trenton, New Jersey

Circle 513 on Page 19

199



Cross section view of typical unbalanced mechanical face seal utilizing Kennametal cemented carbides as seal ring material.

## USE KENNAMETAL\* ...and seal it for certain

When even a *little* leakage matters a lot . . . Kennametal Seal Rings can effect a substantially leakproof seal with a minimum of lubrication. The following characteristics of Kennametal hard carbides may be the key to *your* gas and liquid sealing problems.

### Exceptionally good dimensional stability

Kennametal Seal Rings have no phase change upon heating and cooling because Kennametal has a more homogeneous structure than other commonly used materials. Kennametal Seal Rings can be lapped to a flatness less than half a light band, with a surface finish better than one-half microinch. Because of good dimensional stability, Kennametal Rings *retain* their flatness over an almost unlimited range of operating conditions.

### Successful mating with rings of other materials

When used against opposing faces of graphite or carbon, Kennametal Seal Rings have been found to greatly lengthen the life of the seal. High resistance to abrasion and erosion prevent smearing or grooving out of the seal face.

**Strength without great mass**—The high rigidity of Kennametal materials permits more compact seal designs. A YME of up to 94-million psi (compared to steel's 30-million) permits use of smaller width/smaller thickness rings.

**Corrosion/Wear resistance**—Special Kennametal grades are available for applications involving mild to severe corrosion in combination with abrasion.

**High temperature applications**—Kentanium,† a hard titanium carbide alloy, retains all of the foregoing advantages at higher temperature ranges.

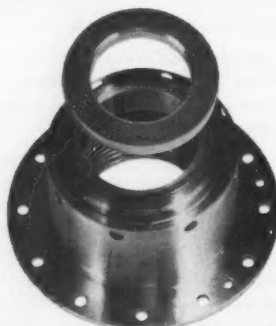
Kennametal Seal Rings have been used successfully for all the following: gases, exotic fuels, fluids, slurries, acids, basic solutions, synthetic and petroleum base fuels, organic solvents, butyl extracts. Chances are we can help *you* with your sealing problem.

Kennametal Seal Rings are available in complete seals from leading seal manufacturers. For more information, send for these booklets: B111A—"Characteristics of Kennametal," B444A—"Kentanium." KENNAMETAL INC., Latrobe, Pennsylvania.

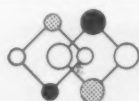
\*Trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.

†Trademark

97253



Balanced seal for high speed/high temperature application, utilizing a Kennametal stationary ring and Kentanium rotating ring.



**KENNAMETAL Inc.**  
LATROBE, PENNSYLVANIA

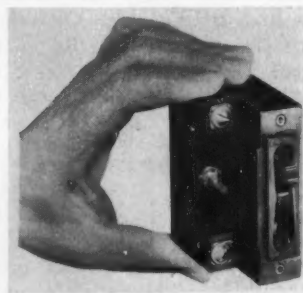
## NEW PARTS AND MATERIALS

and increase printed-circuit reliability. Circuit contact is provided by an integral lug passing through mounting surface either for connection to printed-circuit leads or for solder connection. Each clip pair exerts strong retaining spring action on body of component, pressing shell downward against a small projection in clip which penetrates through films or oxides to clean metal, assuring circuit continuity under extreme conditions of stress. Clip accommodates "top-hat" diodes or rectifier cases from 0.245 to 0.27 in. OD. Atlee Corp., 47 Prospect St., Woburn, Mass. **B**

Circle 697 on Page 19

## Manual Power Switch

is tripped electrically by any type of power



Manual power switch is tripped electrically by practically any type of power from a remotely located control or safety device. Breaker contacts are electrically isolated from coil. Limit control, timer, malfunction detector, or overload condition in one circuit can cause tripping in another interlocked control circuit. Combination power switch-control interlock has an interrupting capacity of 2000 amp at 125 v ac. It is available with either current or voltage-sensing coil. Heinemann Electric Co., 709 Plum St., Trenton 2, N. J. **E**

Circle 698 on Page 19

## Harness-Board Posts

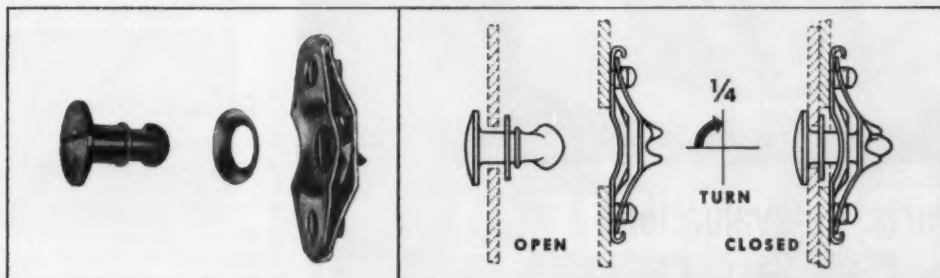
permit rapid preassembly of wiring circuits

Nickel-plated, carbon-steel harness-board posts are driven into harness board as guides to permit rapid pre-assembly of wiring circuits for aircraft components, machine control

THIS PANEL CAN BE  
OPENED OR CLOSED  
IN LESS THAN 2 SECONDS

## LION $\frac{1}{4}$ TURN OPEN $\frac{1}{4}$ TURN CLOSED FASTENERS

ARE FAST, POSITIVE, RELIABLE



Installation of the three parts of the Lion Fastener, shown above, is quick but not critical. Unique in design and performance, these mil spec (MIL-F 5591A-ASG) fasteners make possible quick access and smooth positive locking by only a  $\frac{1}{4}$  turn.

### ALIGNMENT NOT CRITICAL

Both stud and receptacle "float" to accommodate misalignment. The hole, which retains the stud, is twice as large as the stud cross-section. This permits a float of .070 in all directions. The leaf spring receptacle also floats to accommodate stud position.

### WIDE VARIATIONS IN STACK HEIGHT

Total sheet thickness may vary as

much as +.035 and -.015 without affecting operation. A Lion stud, specified for .160 total thickness, for example, will accommodate any stack height between .195 and .145.

### SWAGED-NOSE STUD

Extra strength and smooth operation are made possible by the swaged-nose design. All the metal in the stud goes to work. There are no thin cross pins, holes or milled slots to weaken the cross-section. Case hardening is further assurance of long, trouble-free service.

### WIDE VARIETY

Lion Fasteners are available in 3 sizes—No. 5, No. 2, and Miniature.

An assortment of head styles are supplied—oval, flush, wing, ring, notched or knurled—according to individual requirements.

**FREE!**

**FASTENER  
HANDBOOK**



Send for your free copy of Southco Fastener Handbook No. 9. Gives complete engineering data on Lion Fasteners and other special fasteners. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pennsylvania.

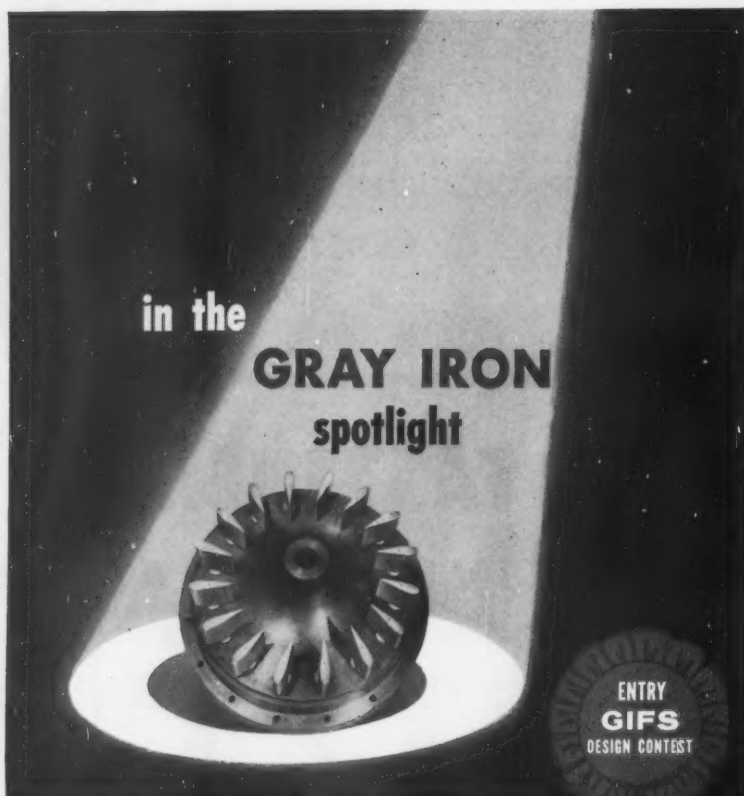
©1959



**LION** *Aviation* **FASTENERS**

one of the

**SOUTHCO**  
**LION**  
**FASTENERS**



## Parts Re-evaluation by Clark Bros. Co. Leads to \$288 Saving

Leading manufacturers like Clark Bros. Co., who consistently re-evaluate their parts fabrication program, always analyse whether difficult-to-process parts can be made better, less expensively, with modern gray iron castings.

An example of the savings possible through an re-evaluation program are these adjustable guide vanes used on Clark centrifugal compressors. Formerly made of SAE 1045 steel, costly shaper and profile milling operations were necessary to complete the part. By using the ability of gray iron to be cast in complex shapes, Clark eliminated machining operations and saved \$18 on each of the 16 vanes.

Start a re-evaluation program in your own plant. Analyse the savings possible by making intricate parts of gray iron. Through cooperative effort with leading GIFS foundries, your progressive foundryman is in the ideal position to make the most worthwhile suggestions.

### FREE DIRECTORY OF PROGRESSIVE FOUNDRYMEN

Lists modern facilities, techniques and types of iron produced by leading gray iron foundries in your area. For a copy write: Dept. G, Gray Iron Founders' Society, Inc., National City-East Sixth Building, Cleveland 14, Ohio.



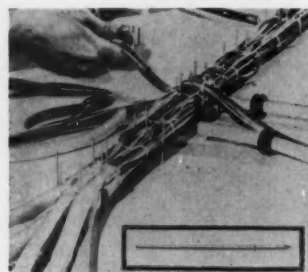
# Specify Modern GRAY IRON CASTINGS

Made by Informed Foundrymen!



Circle 516 on Page 19

## NEW PARTS AND MATERIALS



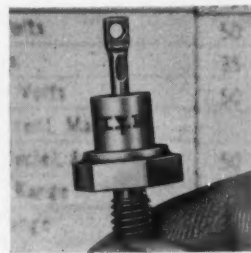
panels, instrument circuits, switchboards, or wherever multiple circuits are preassembled to a diagram. Posts have rounded tops for easier wire placement and removal, and smooth nickel-plated finish prevents damage to insulation. Collar fixes proper, uniform driving depth with or without aid of predrilled holes. Sizes range from 1/2 to 4 in. Dept. TR, John Hassall Inc., Cantiague Road, Westbury, L. I., N. Y. D

Circle 699 on Page 19

### Silicon Rectifiers

operate to base  
temperature of 190 C

Two new series of 6 and 12-amp silicon diffused-junction rectifiers, designed to meet rigid military specifications, operate to base temperature of 190 C. New 6-amp series is designated JEDEC Types 1N1341 through 1N1347, and 12-amp series Types 1N1199 through 1N1205. Both series have peak inverse voltage ranges from 50 to 500 v. All units have low forward voltage drop, low leakage, and high uniformity of characteristics over en-



tire operating-temperature range. Each diode is nickel plated to provide minimum contact resistance and prevent corrosion. Flattened, pierced end on top (anode) lead assures fast, easy wiring into production assemblies. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif. L

Circle 700 on Page 19

## ENGINEERING DEPARTMENT EQUIPMENT

### Pocket Case

holds slide rule,  
pen and pencil

Lightweight leather pocket case holds slide rule, pen and pencil firmly in shirt or coat pocket; eliminates fumbling for loose tools when changing from coat to shirt, from pocket to pocket. A compartment in back holds note-pad or letters. Rule-Wallet is furnished in genuine pigskin. Large steel clip is encased



in leather to protect shirt pockets from soiling. Furnished empty — holds pocket slide rule of conventional make or size. Remco Products, 1641 South Ave., Rochester 20, N. Y.

Circle 701 on Page 19  
N

### Potentiometer Recorder

is wide-strip instrument  
with high flexibility

Dynamaster potentiometer recorder is wide-strip instrument for measuring such variables as pressure, temperature, motion, flow, density, pH, and electric power. Special input-signal selection switches and span adjustments provide maximum flexibility. Four-position input selector switch provides for millivolt, volt, microampere, or milliamperere input. Five-position span selector offers ranges 0-2, 0-5, 0-10, 0-25, and 0-50. An alternate span continuously adjustable from 0.2 to 0.50 is available. An adjustable zero and pushbutton standardization are standard. Automatic standardization (especially desirable for long-duration tests) is optional. Some attachments offered are: Dual-speed chart drive, or mul-

Circle 517 on Page 19→

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# BALL BUSHINGS



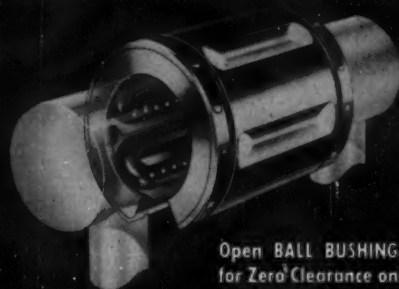
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BALL BUSHING  
for Zero Clearance

The BALL Bearing  
for all your

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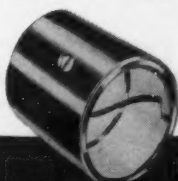
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of DuPont Nylon, and 60 CASE... Hardened and Ground Steel Shafting

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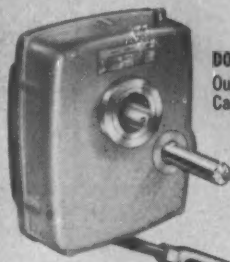
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**LIFETIME GEARING\***



**SINGLE REDUCTION**

Output Speeds: 90 to 420 RPM  
Capacities: 1/4 to 40 HP



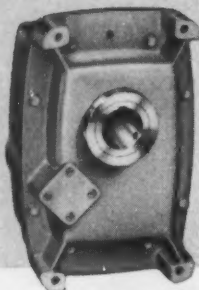
**DOUBLE REDUCTION**

Output Speeds: 10 to 160 RPM  
Capacities: 1/4 to 30 HP

**DOUBLE REDUCTION**

**FLANGE MOUNT**

Output Speeds:  
10 to 135 RPM  
Capacities:  
1 to 7 HP



Foote Bros. Shaft Mounted Drives offer more efficient, more economical, power transmission. They incorporate exclusive **Duti-Rated** Lifetime Gearing—the high hardness, balanced design, premium quality gearing that combines greater load carrying capacity with long service life.

Used with standard V-Belts and Sheaves, Foote Bros. Shaft Mounted Drives will provide virtually any output speed you may require. Quick, easy installation on driven shafts with diameters from 15/16" to 3-7/16" saves time, labor . . . eliminates need for reducer mounting, couplings, and adjustable motor mount. Built-in Backstop to prevent reverse rotation, Automatic Overload Release Torque Arm, Variable Pulley, are available as optional equipment.

The complete Foote Bros. Shaft Mounted Drive line is made in accordance with all applicable AGMA Standards

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FOOTE BROS.

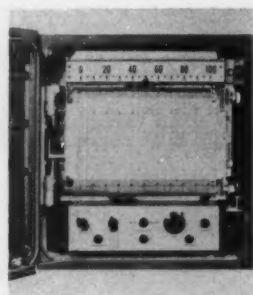


GEAR AND MACHINE CORPORATION

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POWER TRANSMISSION DRIVES

ENGINEERING DEPT. EQUIPMENT



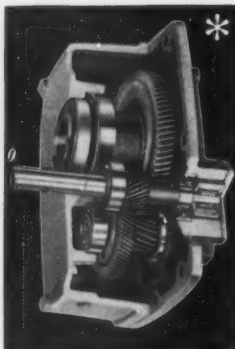
tispeed chart drive (six speeds); time pen (for marking reference points in testing); chart-footage indicator; manual chart rewind; manual or electric pen lifters; and retransmitting slidewires. Bristol Co., Waterbury 20, Conn. B

Circle 702 on Page 19

### Electronic Computing System

general-purpose unit  
is fully transistorized

RCP-4000 digital transistorized electronic computing system operates on nine-digit numbers at rates up to 240,000 operations per minute. Over-all high computing speed results from high operating rates, versatile command list, index register that allows high-speed instruction modification, repeat execution, high-speed input-output equipment, and eight-word accumulator for block operation. Magnetic drum memory section is encased in a metal shroud to protect it from dust particles or accidental damage. Memory has storage capacity of 8,008 words, allowing great problem-solving flexibility. Variety of programs can be stored permanently for instant access when needed. Average access time to main storage is 8.5 millisec. Standard input-output equipment includes tape typewriter system complete with typewriter, desk, tape punch-read console, and chair. Basic reader speed is 60 characters per sec, and basic



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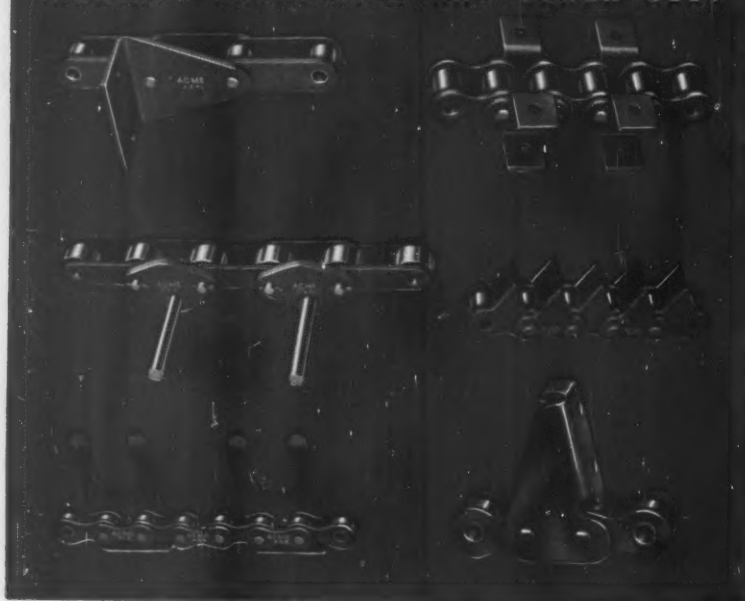


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Circle 520 on Page 19

### ENGINEERING DEPT. EQUIPMENT

punch speed is 30 characters per sec. Data Processing Div., Royal McBee Corp., Westchester Ave., Port Chester, N. Y.

Circle 703 on Page 19

### Vertical Safe

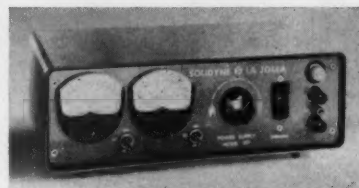
holds up to 1000 blueprints

Vertical blueprint safe,  $58\frac{1}{4}$  in. high,  $23\frac{1}{4}$  in. wide, and  $36\frac{1}{2}$  in. deep, holds up to 1000 plans in a fireproof, burglarproof compartment. Prints are retained on 30-in. long, removable steel Glider plan holders for quick vertical filing. Evenly spaced thumbnails on plan holders tension-hold prints to 30 in. wide and 48 in. long. Plan holders are retained from end-to-end in all-steel channels, with no chance of bending or springing. Momar Industries, 4176 W. Montrose Ave., Chicago 41, Ill.

Circle 704 on Page 19


### DC Power Supply

for transistor-circuit work



Compact power supply is designed primarily for transistor circuit work and applications where recurrent spikes and other transients would damage equipment under test. Voltage and current meters are provided for accurate setting of output voltage and continuous monitoring of load currents. Output is adjustable from 5 to 35 v with a maximum current of 2 amp. Either the positive or negative terminal may be grounded, or the output can be floating. Regulation is better than 0.1 per cent, and variation in output voltage is never more than 30 mv. Ripple is held down to less than 1 mv. Model PS 201 weighs approximately 14 lb; occupies less than a square foot of bench space. Fast circuit breaker with manual reset provides protection against load short-circuit. Solidyne, 7460 Girard Ave., La Jolla, Calif.

Circle 705 on Page 19



## frozen lightning

*That's what the Germans call the stratosphere trails of high altitude rockets. Soon, Mach 4-5 aircraft will be cutting frozen lightning trails across our own skies. Structural parts of hypersonic aircraft and missiles must function perfectly at temperatures too high for ordinary alloys.*

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Webb Wire Division, New Brunswick, N.J.  
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## THE ENGINEER'S

# Library

### Recent Books

**Calculus with Analytic Geometry.** By Donald E. Richmond; 458 pages, 6 1/4 by 9 1/4 in., clothbound; published by Addison-Wesley Publishing Co. Inc., Reading, Mass.; available from MACHINE DESIGN, \$8.75 per copy.

Since no knowledge of trigonometry or analytic geometry is presupposed, early chapters include fundamentals such as functions and graphs, derivatives, and area under a curve. Later chapters are devoted to integration, differential equations, vectors, partial derivatives, and series.

**Nature and Properties of Engineering Materials.** By Z. D. Jastrzebski, professor of chemical engineering, Lafayette College; 571 pages, 6 by 9 1/4 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from MACHINE DESIGN, \$11.00 per copy postpaid.

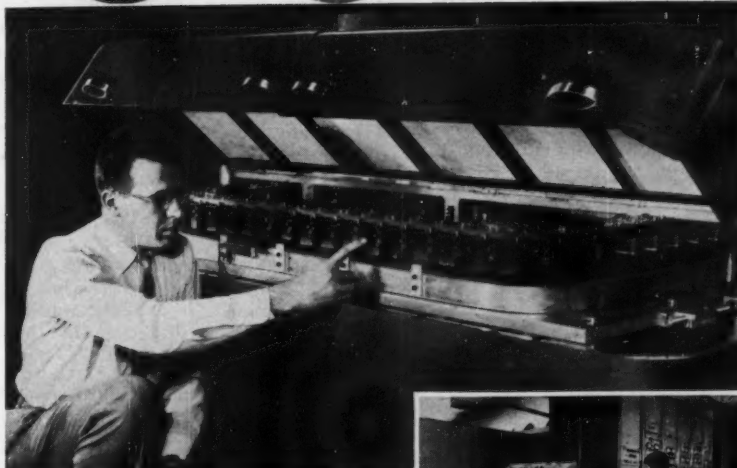
Basic principles necessary for an understanding of the fundamental nature and properties of engineering materials are emphasized. Early chapters deal with elementary theory of atomic structures and forces. Later chapters are devoted to mechanical properties, metals, ceramic and related materials, electrical and magnetic properties, thermal properties, friction, wear, and lubrication.

### New Standards

**American Standard, ASA C39.1-1959, Requirements for Electrical Indicating Instruments, Panel, Switchboard, and Portable Instruments.** 52 pages, 8 1/2 by 11 in., paperbound, stapled; published by and available from The American Standards Association, 70 East 45th Street, New York 17, N. Y.; \$2.50 per copy.

Standards in this revised fifth edition\* apply to dc and ac ammeters, voltmeters, wattmeters, varmeters, frequency meters, power-factor meters, and other instruments operat-

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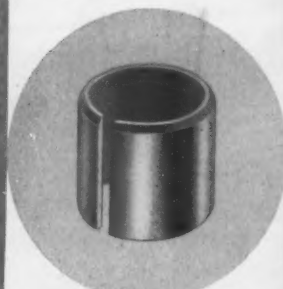
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ing on same principles but indicating derived quantities. Also covered are special - purpose instruments such as ultrasensitive direct-current microammeters and thermovoltmeters of the vacuum-couple type. Not covered are indicating instruments provided with arrangements for curve drawing, contact making, etc., and small instruments where indications are approximate.

American Standard, ASA C83.16-1959, Definitions and Terminology for Relays. 29 pages, 8½ by 11 in., paperbound, stapled; published by and available from The American Standards Association, 70 East 45th Street, New York 17, N. Y.; \$2.00 per copy.

Definitions of electromagnetic, thermal, magnetostrictive, and electric field relays, and approximately 200 other terms associated with relays are given. Several diagrams are used to clarify definitions. Definitions previously established in other contemporary standards are excluded from scope of this new standard.

### Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

FB 151436. Development of Foamed-in-Place Plastic Energy Absorbing Materials. By R. C. Bryant, W. D. Stewart, and others. Atlantic Research Corp.; 80 pages, 8 by 10½ in., paperbound, side-stapled; \$2.00 per copy. Foamed-in-place, rigid polyurethanes with equal or better cushioning properties than foamed glass of the same density can be produced by a technique developed for the Army. Also described is a drop tester used to screen experimental and commercial products.

FB 151715. Thermophysical Properties of Solid Materials. By Alexander Goldsmith and Thomas E. Waterman. Armour Research Foundation; 430 pages, 8½ by 10½ in., paperbound, side-stapled (punched for 3-ring binder); \$6.00 per copy.

This preliminary volume represents the first year's work in a program to compile and evaluate all original test data published since 1940. In general, only materials melting above 1000 F are included. Exceptions are plastics or composite materials. Data are uniformly presented in tabular and graphical form. Items covered are pure elements; iron base alloys; nickel-base, cobalt-base, and refractory-base alloys; light-metal alloys; ceramics; cermets; intermetallics; polymeric materials, including plastics; and composite materials.

FB 151756. Corrosion Prevention—Part M of Maintenance and Operation of Public Works and Public Utilities. 431 pages, 8 by 10½ in., paper covered, Accopress binder; \$6.00 per copy.

This manual provides information on the latest methods and techniques for amelioration and control of atmospheric, submerged, and subsurface corrosion, and of corrosion in areas alternately wet and dry. Among corrosion processes discussed are those caused by use of dissimilar metals, with particular emphasis on the EMF series and galvanic corrosion, direct chemical attack, stray currents, microbiological and atmospheric attack, and marine corrosion. Tables presented in Appendix A give data on the causes of corrosion and mitigation methods for stationary and floating marine structures.

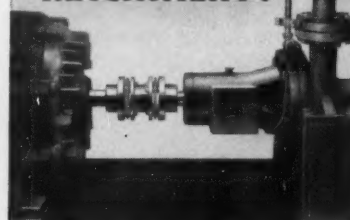
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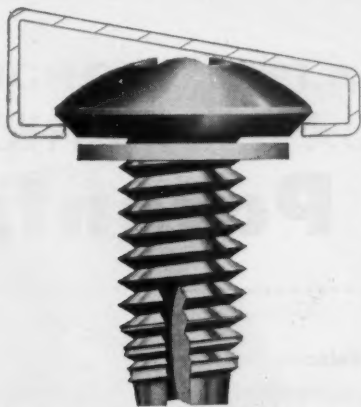
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LOOK TO SHAKEPROOF - THE LEADER IN FASTENING

Circle 525 on Page 19

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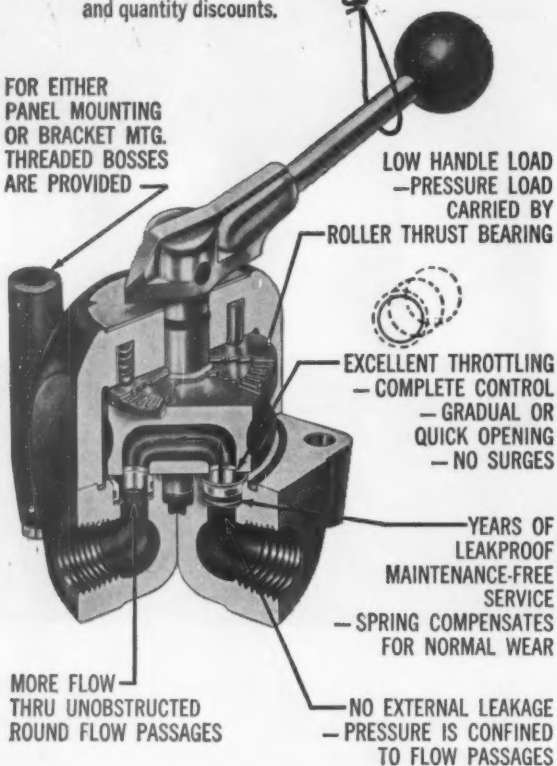
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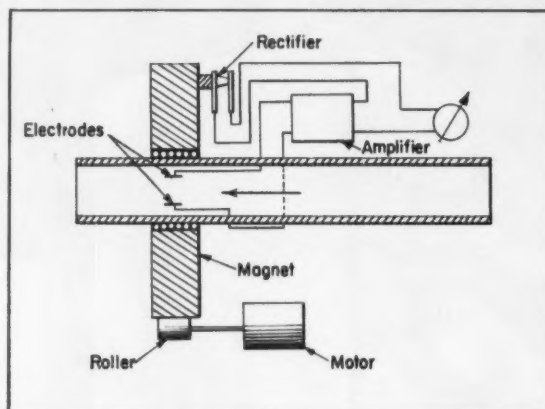
5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

NOTEWORTHY

## Patents

### Fluid-Velocity Indicator

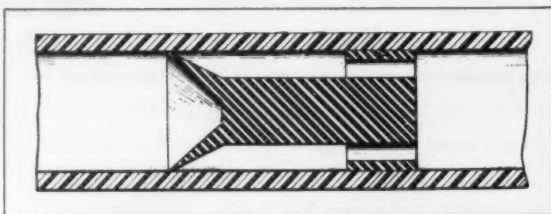
Direct indication of fluid velocity is provided by voltage induced by fluid flow between the electrodes within the line. A mechanically driven permanent magnet estab-



lishes a rotating magnetic field. The rotation of the field avoids polarization of the electrodes. A rotary rectifier permits use of a direct-current meter to measure the voltage. Patent 2,907,207 assigned to North American Phillips Co. Inc., by Herre Rinia.

### Nonmetallic Check Valve

A tubing insert of rubber, vinyl, or polyethylene has a flexible portion which extends angularly from the



stem to contact the inner portion of the tubing wall. The flexible lip is forced into the closed or open position depending upon the direction of fluid flow. Patent 2,913,000 assigned to Don Baxter Inc., Glendale, Calif., by Martin Roberts.

### Hydraulically Controlled Belt Drive

Smooth and positive speed changes are provided by simultaneous hydraulic actuation of both sheaves in a variable-speed belt drive. Force applied to the control lever actuates one sheave directly. Two hydraulic cylinders and a connecting line transmit the force to the

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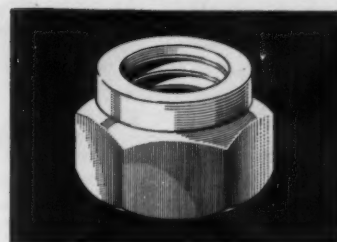
Because they require no auxiliary locking devices, precision microsize FLEXLOCs (shown actual size—over 4000 of them) simplify design, save weight and space, help eliminate costly specials. Positive action of locking collar assures a high degree of mechanical reliability.

**Require no separate locking devices  
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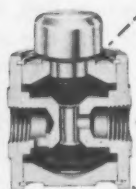
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**SPS**  
where reliability replaces probability

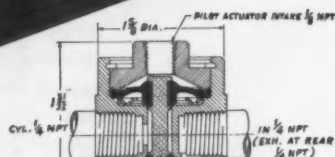
SIZE	Across Flats		Hex. Height	Across Corners	
	MAX.	MIN.	REF.	MIN.	REF.
0-80 NF-3B	.111	.107	.046	.121	.075
1-64 NC-3B	.127	.123	.056	.140	.090
1-72 NF-3B	.127	.123	.056	.140	.090
2-56 NC-3B	.158	.153	.067	.176	.105
2-64 NF-3B	.158	.153	.067	.176	.105
3-48 NC-3B	.190	.183	.071	.210	.120
3-56 NF-3B	.190	.183	.071	.210	.120
4-40 NC-3B	.190	.183	.071	.210	.120
4-48 NF-3B	.190	.183	.071	.210	.120

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**"Quick-Dump"**  
 Valves Provide  
**NEW FLEXIBILITY**  
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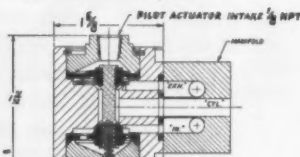
Same Basic  
 Valve Design  
 Used in  
 All Models



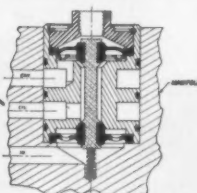
Choice of Manual,  
 Electric, Piloted  
 Operation



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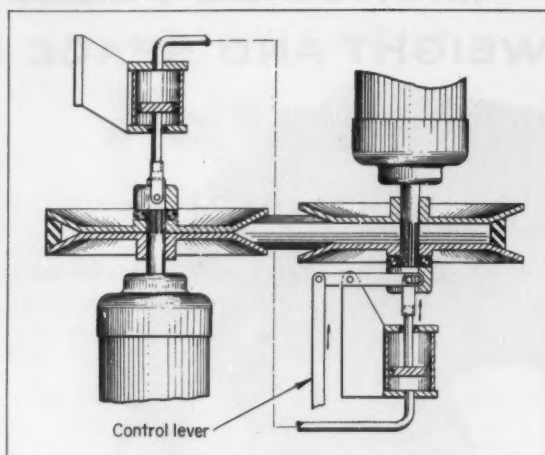
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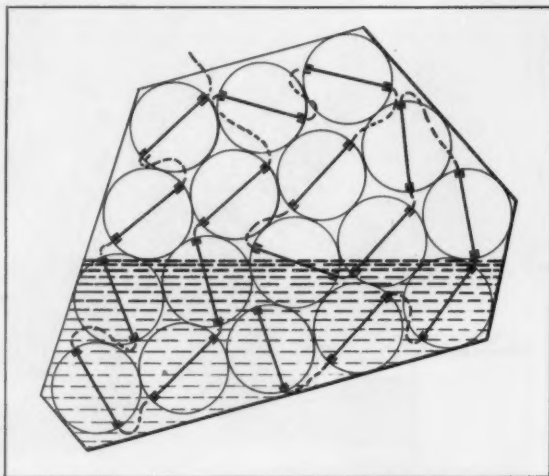
NOTEWORTHY PATENTS



companion sheave. The hydraulic cylinders could also be connected to an external hydraulic power source to provide power-actuated speed changes. Patent 2,916,927 assigned to the Dayton Rubber Co., Dayton, Ohio, by Lincoln I. Oppen.

**Liquid-Quantity Gage**

Regardless of the attitude or position of an odd-shaped tank, the quantity of liquid within it can be determined by an electrical device. The tank is filled with small

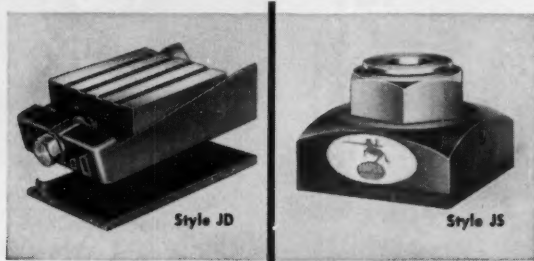


spherical capacitors, which are of an open-work character. The difference in capacitance when these capacitors are filled with liquid as compared with air, provides a means of electrically measuring the amount of liquid within the tank. Patent 2,910,869 assigned to the Liquidometer Corporation, Long Island City, N. Y., by William C. Anderson.

**Component Mounting Clamp**

Easy installation of mounted parts in hard-to-reach places is provided by a special shaped clamp. A resilient sleeve serves as a friction grip to prevent free rotation of the clamp. When the clamp is tightened,

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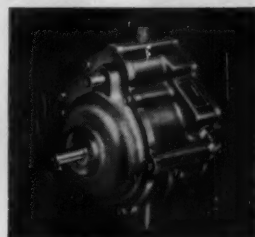
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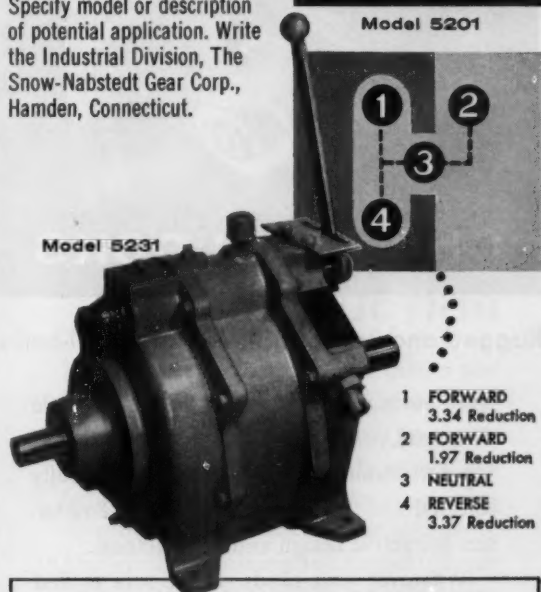
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Model 5108



Model 5201



Model 5231

- 1 FORWARD  
3.34 Reduction
- 2 FORWARD  
1.97 Reduction
- 3 NEUTRAL
- 4 REVERSE  
3.37 Reduction

### SPECIFICATIONS

MODEL NO.	5231	5201	5108
Reduction Forward	1.97:1 & 3.34:1	3.16:1	3.75:1
Ratio Reverse	3.37:1	3.16:1	3.75:1
Power Up To	28 HP	28 HP	8 HP
Maximum Input Torque	1000 in. lbs.	1000 in. lbs.	320 in. lbs.
Maximum Input Speed	2400 RPM	2400 RPM	2400 RPM
Long Dimensions	15 1/4"	11 1/2"	9 1/4"
Wide	14"	12 1/2"	10"
High	14 3/4"	14 3/4"	10 3/4"



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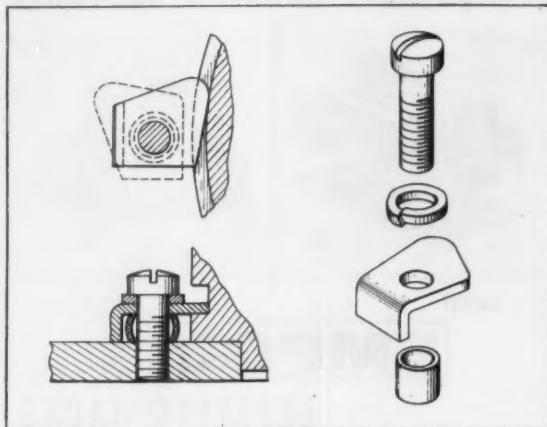
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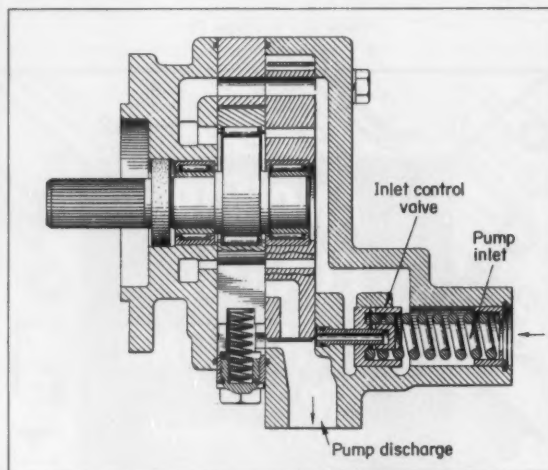
### NOTEWORTHY PATENTS



the single ear bears against the component to prevent further turning. As the clamp is loosened, it gradually turns to an out-of-the-way position to permit removal of the component. Patent 2,917,267 assigned to Librascope, Inc., Glendale, Calif., by Joseph E. Riddle.

### Variable-Discharge Pump

Discharge of a vane pump is controlled by pressure-actuated regulation of the pump inlet. An increase in discharge pressure moves the regulating valve to



restrict the inlet. The valve also provides pressure relief by connecting the discharge and the inlet passages at a predetermined discharge pressure. Patent 2,916,999 assigned to General Motors Corporation, by Howard W. Christenson.

### Chatter-Free Check Valve

A booster piston provides variable operating area to give positive response of a main valve to slight pressure variations. When inlet pressure exceeds outlet pressure, the booster piston provides additional force to hold the main valve open. When the outlet pressure becomes equal to or greater than inlet pressure the booster piston does not affect the closing of the main

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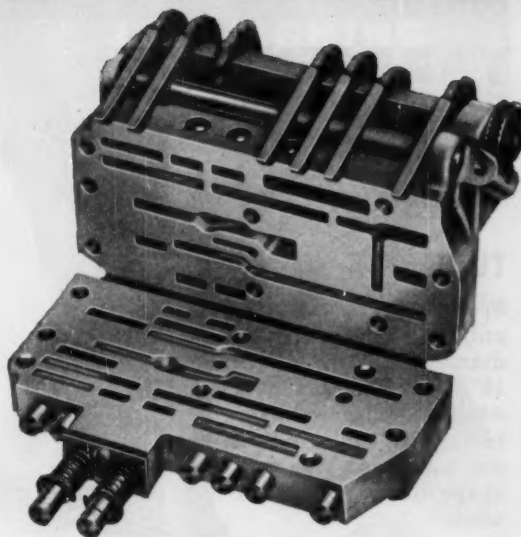
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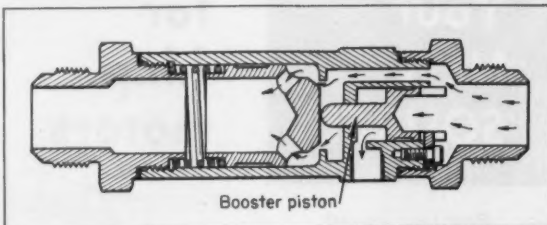
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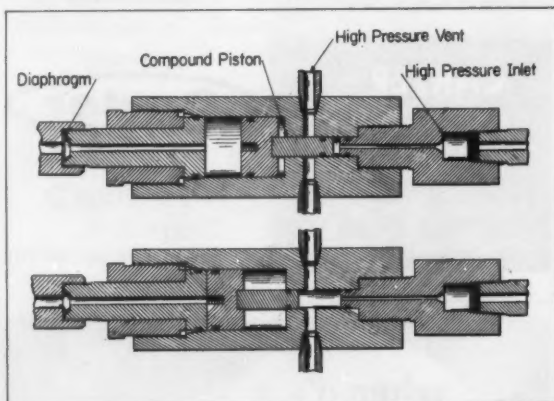
### NOTEWORTHY PATENTS



valve. Patent 2,916,046 assigned to United States of America (Air Force) by Clement J. Turansky and Sylvester J. Pirrone.

### Extreme-Pressure Relief Valve

A compound piston and cylinder arrangement permits use of a regular high-pressure diaphragm to control extreme pressures. High pressure against a small



piston produces lower pressure in large cylinder. Rupture of diaphragm at predetermined pressure allows compound piston to move, uncovering port to vent high-pressure portion of system. Patent 2,912,992 assigned to Autoclave Engineers Inc., Erie, Pa., by Fred Gasche and Robert L. Porter.

### Vibration Isolator

Vertical and horizontal damping as well as stiffness are controlled independently in a component mount to isolate shock or vibration. A spring ring inside the vertical-damping bushing controls vertical damping. Horizontal damping results from the friction force between the curved portion of the supported member and the curved portion of the vertical-damping bushing. Stiffness is controlled independently by concentric coil springs which share the weight of the supported equipment. The inner spring controls horizontal stiffness while the outer spring controls vertical stiffness. Patent 2,917,265 assigned to Barry Controls, Inc., Watertown, Mass., by Edwin P. Markowski.

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.



SK Fig. 1853 Purge Rotameter. Rate of fluid flow is indicated by position of ball float in relation to scale beside tube.

SK Purge Rotameters for indicating and manually controlling small flows are competitively priced yet give these advantages—stainless steel internal parts... positive back flow check valve... effective flow control valve... removable tube feature. Available with differential regulator for automatic control of purge rate of flow. Also supplied in lucite and Kel F. Write for new Bulletin 18P.

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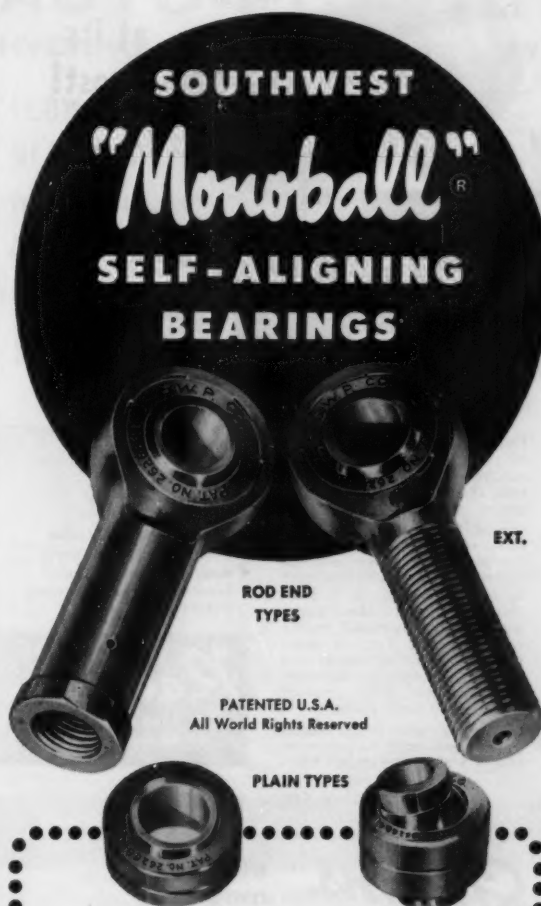
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#### ANALYSIS

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- 2 Chrome Alloy Steel Ball and Race
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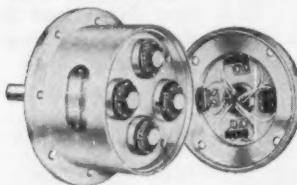
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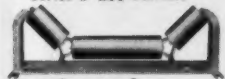
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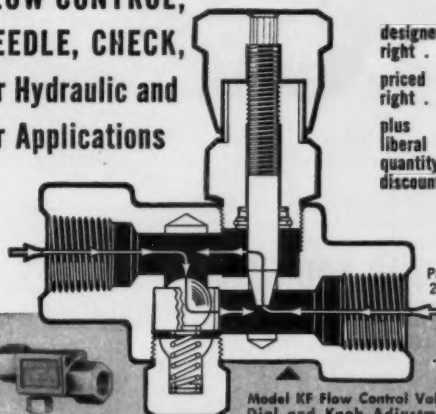
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2,841,174

Model C Check Valve  
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Figure 1



Figure 2

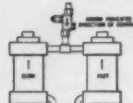


Figure 3

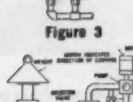


Figure 4

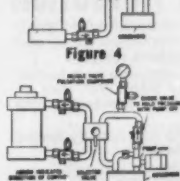


Figure 5

**MINIMUM PRESSURE DROP AND POWER LOSS**  
... Oversize ports and passages give maximum flow at minimum pressure drop, insure accuracy and response in hydraulic or large volume air cylinder control.

**EASY FLOW ADJUSTMENTS** under full pressure. Seal located at port to eliminate air or dirt traps. Gland structure equally effective on pressure or vacuum.

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Fig. 4—RETURN SPEED CONTROL, typical hydraulic hoist

Fig. 5—Various uses of AUTO-PONENT Valves in hydraulic power systems

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221

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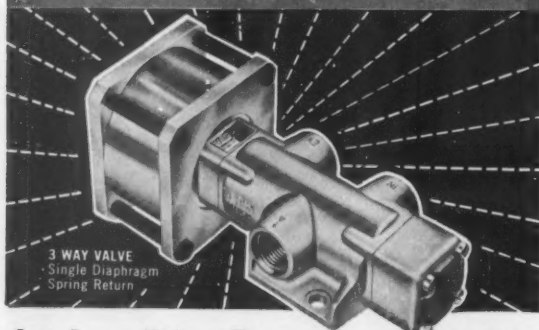
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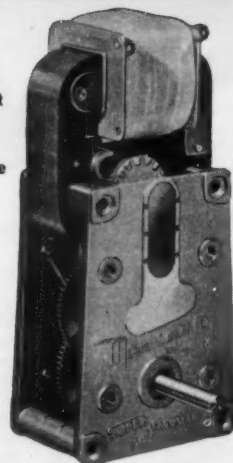
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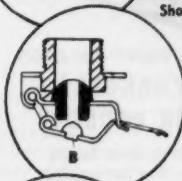
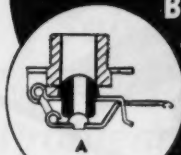
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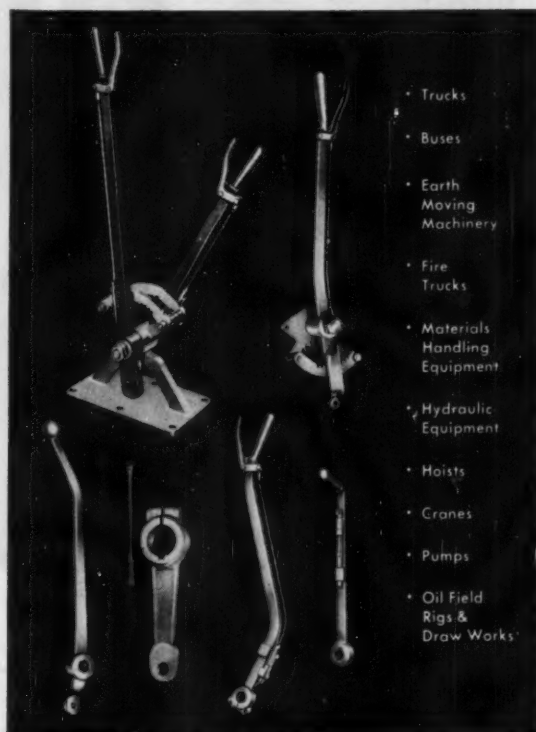
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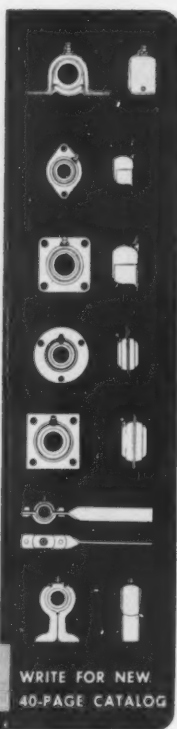


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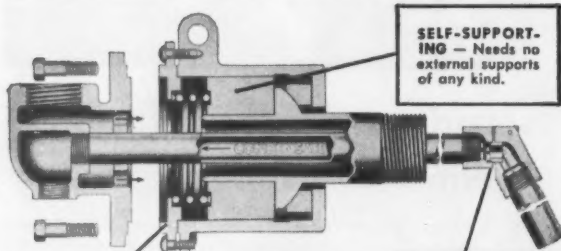
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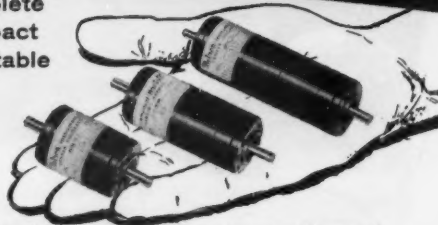


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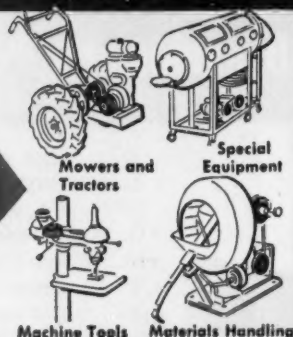
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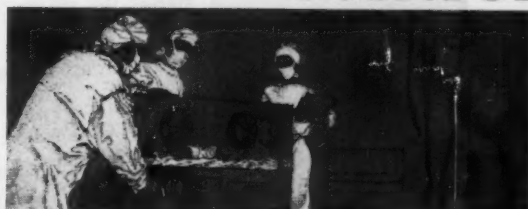
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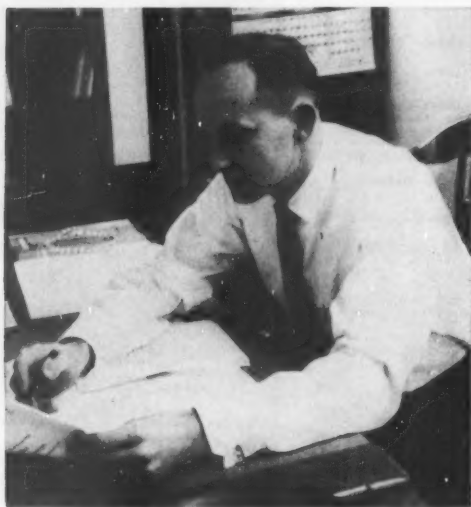
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# backtalk—

## —Meet a New Editor

The intent fellow poring over a deskful of manuscripts is Donald R. Dreger, newest assistant editor of MACHINE DESIGN. Don has been preparing for this job for a long time. He attended Ohio State University, then trans-



ferred to Case Institute of Technology, where he earned a B.S. degree in mechanical engineering. For about seven years he served in various capacities, including chief engineer, at Ovens for Industry Inc., a Cleveland designer and builder of industrial process equipment. He next had a go at private enterprise, also in the process equipment field.

Just before joining MD, Don worked for Dramaturgy Inc., which he describes as "industrial theatre." Exhibitors at trade shows have learned that their booths attract more attention if they have moving parts (which don't always have to be girls). Don's job was to engineer such exhibits.

Don came to us with printer's ink already well mixed into his blood—he has a small press in his basement, where he does letterpress and silk-screen printing as a hobby.

## —From the Pens of Babes

A little girl in Minneapolis, who didn't explain why she selected us, wrote to ask for information about "fashions, *extra*," because she is thinking of entering this field when she

is older. She's doing *research* on it and would appreciate booklets, *pamphlets* and *othere information*.

The request was referred to one of our lady editors, who is offering help on obtaining the booklets and pamphlets on fashion, but is also suggesting to the little girl that she consider a career in engineering. After all, she shows unusual curiosity, resourcefulness, and initiative—for a girl. And her spelling is already up to par.

## —Looking for Something?

If you are, and if the something happens to be an article published in MACHINE DESIGN last year, we have just the thing for you: A copy of our index of editorial content for 1959. This index was included in the December 24 issue, and it is also available as a separate reprint, which is yours for the asking. Just dash off a letter or card to: Reader's Service, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio, or scribble "Annual Index" on one of the yellow cards on Page 19.

## —Cop a Prize with Copper

Disproving the old penny-wise, pound-foolish tale, someone who is copper-wise will also benefit dollar-wise from the second annual Copper and Brass Achievement Award, announced by the Copper & Brass Research Association. Winner of this competition will receive a bronze award and \$1000 for the year's most significant advance in the use, application, or metallurgy of copper, brass, bronze, or other copper-base alloy.

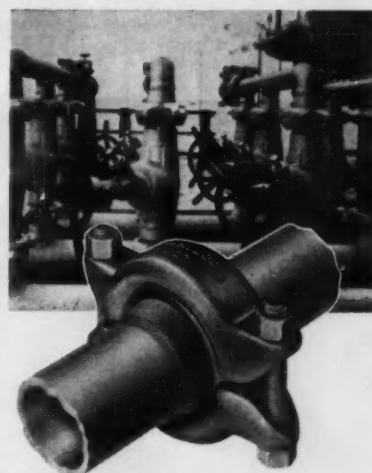
Entries and nominations may be submitted in several classifications, such as development of new products in which copper or its alloys are important, contribution to the metallurgy of the copper metals, improvement of production or fabrication techniques, or contribution to the advancement of science or research through application of the copper metals.

Last year's award was given in recognition of the world's first all-bronze skyscraper, the Seagram Building in New York City.

Entry forms are available from the Copper & Brass Research Association, 420 Lexington Ave., New York 17, N. Y. Nominations should be mailed by March 31.

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## GRAYLOC® SAVES 3 WAYS FOR OEM

Original Equipment Manufacturers save on space, weight, and time when reliable GRAYLOC is specified for piping connections for their products.

The compactness gained with space-saving GRAYLOC might make your product adaptable to more applications. Example: Five Grayloc-equipped valves can be installed in the space normally used for four flange-type valves in a manifold hook-up.

Weight-saving GRAYLOC makes many units easier to handle, certainly it will save you freight costs since GRAYLOC weighs up to 90% less than comparable-sized flange connections. Yet there is no loss of strength. Example: 4-inch GRAYLOC with a rating of more than 6,000 psi weighs 35 pounds compared to the 450 pounds of a flange connection with a comparable rating.

GRAYLOC connections can be made up in as little as 3 minutes time by unskilled laborers and are positively leak-proof every time.

GRAYLOC connections have practical applications wherever flanges are used. For additional information concerning the savings you can have with GRAYLOC, contact Gray Tool Company.

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Circle 565 on Page 19→

*After years...if you do have to "repack"*  
**JUST REPLACE 2 SELF-CONTAINED UNITS**  
**IF IT'S A HUNT PDQ AIR VALVE**



You want an air control valve that **one man can completely repack in a minute** on the bench or on the line.

We have that valve for you.

To repack the HUNT PDQ you just slide two simple self-contained units into place. One . . . the poppet spindle-sleeve assembly. Two . . . the plug-in solenoid pilot assembly. That's all!

You want a minimum inventory of spare parts. With the HUNT PDQ valve you stock **only two spare units** . . . not several dozen parts.

One man . . . any man . . . can completely repack the PDQ (including the solenoid pilot section) in less time than it takes you to read this ad. And your line is back in operation again.

This is the valve you want and need. Write today for the full story on the PDQ.

A. V. Ney, Sales Manager

HUNT VALVE COMPANY • SALEM, OHIO, U. S. A.

- ☒ Accessibility
- ☒ Simplicity
- ☐ Speed and Capacity
- ☐ Price and Quality

The Hunt PDQ valve tops them all in every class.

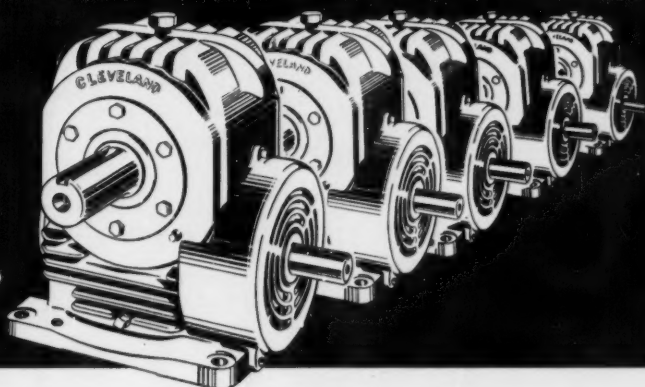
Next month . . .  
 the SPEED and CAPACITY story.

**HUNT**



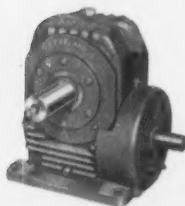
**Quick-As-Wink** AIR & HYDRAULIC CONTROL VALVES

Why do these  
new Cleveland  
carry higher  
horsepower ratings?



It's because Cleveland design engineers — drawing on 47 years of experience — have successfully blended the *just right* combination of housing design, exclusive heat-treatment for alloy steel worms, centrifugal casting of bronze gear rims together with larger, more rugged taper roller bearings on worm and gear shafts.

This permits substantially higher horsepower ratings with smaller worm and gear units — units that more than meet AGMA's new Standard 440.03. Cleveland now offers speed reducers — from one to forty horsepower — at savings of 50% or more on cost per horsepower.



**HOUSING** is a rugged one-piece design of highest quality cast iron, ribbed for maximum strength and heat dissipation. Cooling fan

of unique design is mounted on *input* end of worm shaft and is equally efficient in either direction of rotation. Only one gear shaft bearing plate is large enough to permit assembly of the gear. On gear shaft extension side, gear shaft bearing is mounted in the housing bore and backed up by a clamping plate. This gives a stronger housing and provides maximum strength for overhung loads. Housings are designed for mounting in one position only, thus avoiding design compromises necessary with *universal mount* types.



**BEARINGS** on both worm and gear shafts are Timken taper roller-type, providing adequate thrust and radial capacity. Worm bearings are mounted directly in housing bore for greater rigidity.



**WORMS** are cut integral with shaft and accurately ground to a high surface finish on both thread flanks. Shaft extension diameter is especially large to permit increased overhung load capacity. An exclusive heat-treating technique provides a high degree of hardness throughout the entire thread thickness and well below the worm's root diameter. It gives maximum thread strength and resistance to wear without losing the advantage of a tough core of medium hardness.



**GEARS** have centrifugally cast bronze rims with a high tin-nickel content. They provide greater density and a higher hardness, giving increased resistance to wear and fatigue pitting. Bronze rims are centrifugally cast integral with cast iron centers, in smaller sizes up to 6 inches, which permits strong mechanical keying of the two parts — without dependence on actual surface bond. Gear shaft extension diameters are especially large to permit greatly increased overhung load capacity.

**ORIGINAL MASTER WORMS** for each size and ratio of worm gearing, are made individually in Cleveland's tool room to extremely close tolerances and kept in perpetual stock. Cleveland makes all their hobs. No outside source has been found that can produce worm gear hobs to their exacting tolerances and standards. Each hob is checked against this master worm — as are production worms and gears. Thus, it's not necessary to ever replace Cleveland worms and gears in sets. A new gear will operate perfectly with an old worm and vice versa.

Call your Cleveland Representative today, to get all the facts on these new, more powerful speed reducers. Or, write for a copy of new, free Bulletin No. 405 giving complete engineering information.

The Cleveland Worm & Gear Company,  
3287 E. 80th St., Cleveland 4, Ohio.



A subsidiary of  
Eaton Manufacturing Company

**CLEVELAND**  
Worm Gear  
*Speed Reducers*

Affiliate: The Farval Corporation

New Repeat Accuracy . . . the Cutler-Hammer 10316 Precision Limit Switch always trips at the same point of "in" and "out" plunger travel.



## NEW HIGH PRECISION in a NEW PRECISION LIMIT SWITCH

- LASTS 10 TIMES LONGER
- CAN'T TEASE
- TRIPS REPEATEDLY AT  
PRECISELY THE SAME POINT

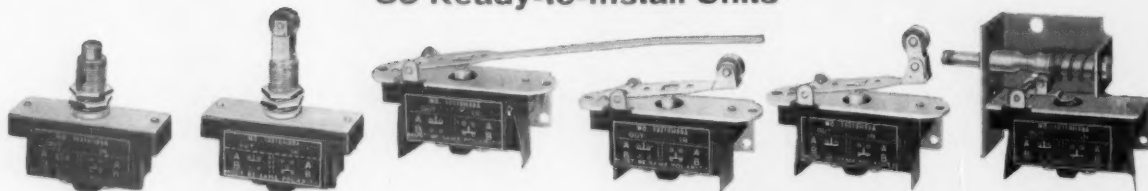
The new 10316 will change your ideas about what an industrial duty precision limit switch can do.

Comparative tests proved the 10316 provides ten times greater life. It could not be teased. And it always fired at exactly the same points of "in" and "out" plunger travel. Prove it yourself! You'll discover a *new high* in electrical and mechanical life, the sureness of repeat action, the utter dependability of the Cutler-Hammer 10316 Precision Limit Switch.

Three dimensionally identical switch bases are available. Double circuit switch is normally open—normally closed. Single circuit switches are either normally open or normally closed. A wide variety of operators, with various individual mountings, provide easy-to-install units meeting practically every type of application.

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**6" Lever** can be formed on-the-job to satisfy unusual needs.

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